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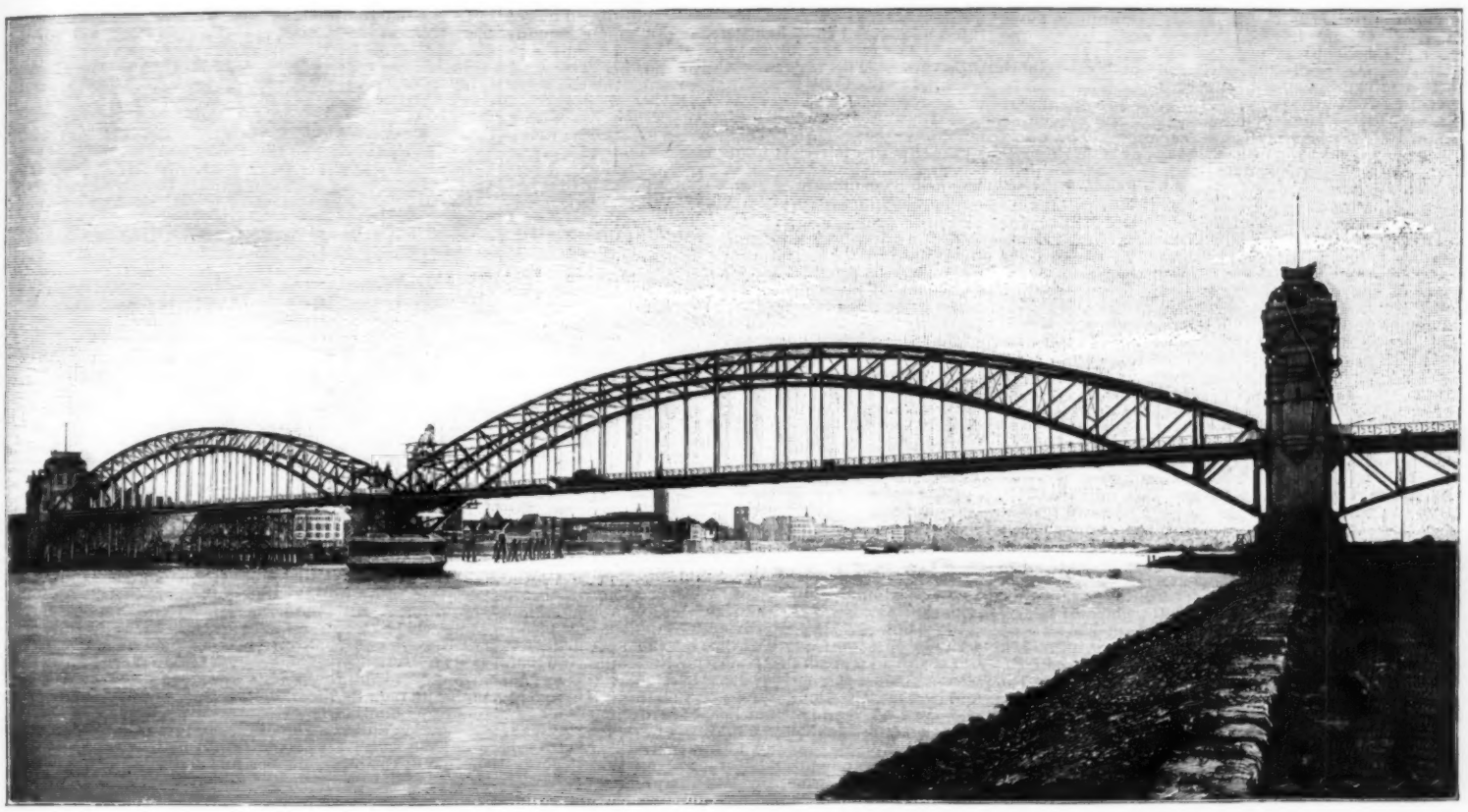


NORTH SIDE OF THE TWO MAIN ARCHES—THE CITY OF DÜSSELDORF IN THE REAR.

SOUTH SIDE OF THE BRIDGE VIEWED FROM THE LEFT BANK.

THE NEW BRIDGE OVER THE RHINE AT DÜSSELDORF.

THE NEW DÜSSELDORF BRIDGE OVER THE RHINE.

FOR the last fifty years, more than one project has been formed to build a bridge across the Rhine at Düsseldorf. Six attempts were made in this direction; but the plans formed were never carried out. Finally the Rheinische Bahngesellschaft, proprietors of the Düsseldorf-Krefeld electric railway, undertook the task, and in two and one-half years completed the present bridge from the designs of Prof. R. Krohn.

Prof. Krohn is chief engineer of the Gutehoffnungshütte. The Bonn bridge, built under his supervision, is, with the exception of the Niagara structure, the largest arch bridge ever built. The type of arch found in this bridge, as well as in the Düsseldorf bridge, was for the first time used in large spans by Prof. Krohn. Similar designs have carried away first prizes in competition bids. Prof. Krohn must also be given credit for his efforts in introducing open hearth steel in German engineering.

The two great arches extending across the stream at Düsseldorf, each having a span of 182·25 meters, rest upon three piers. The bridge-approach on the right bank contains an arch which has a span of 60 meters, and which extends across the roadway running along the river. On the left bank three arches extending across the flats, to permit the passage of the flood waters, connect the bridge with the street leading to the new railway-station of Oberkassel. The foundations of five of the seven bridge-supports were laid by means of caissons sunk 3·5 meters. For the other two supports the caissons were sunk 13 meters. The upper chords of the two main arches have, at their highest points, an elevation of 42 meters. The bridge-roadway between the end piers is 636 meters long, and is 7·5 meters higher than the tallest mast, 11·5 meters higher than the tallest smokestack. From rail to rail the roadway is 14·2 meters wide, of which 8·2 meters are taken up by the railway, and 3 meters by each of the two foot-paths. The horizontal distance between the chords of the two supporting arches, from center to center, is 9·7 meters; the suspension cables are spaced 7·25 meters apart. In building the iron superstructure 5,000 tons of steel were required, of which 1,600 tons were used in the main arches. The bridge-towers are built with two huge stone archways, in the Renaissance style. On the mid-stream pier, facing the south, the arms of the city of Düsseldorf (a lion sejant, holding an anchor and escutcheon) have been placed.

The bridge taken as a whole is lacking in unity and balance. The short central pier at the meeting of the two main spans causes each arch to appear smaller than it would if standing alone. The unequal division of the adjacent openings (3:1) disturbs the artistic symmetery of the structure. But the peculiar conditions which obtained prevented a more æsthetic arrangement.

The entire cost of the bridge was 6,000,000 marks. Although four kilometers of water frontage are owned by the railway company, the annual income of the invested money is not more than 80,000 marks—a sum insufficient to pay the interest on the capital. The enterprise will prove more profitable only when the Düsseldorf-Krefeld electric railway shall use the bridge in transporting its passengers from the one city to the other.

We are indebted to Ueber Land und Meer for our information.

COAST-TELEGRAPHS AND SPACE-TELEGRAPHY.

THE year 1898 was an important period in the history of space-telegraphy, it was the period in which the possibility of being able to signal across wide stretches of open sea, with certainty in all weathers and at high speeds, became first generally recognized as practicable. Within the year the final report of the Royal Commission on the question of coast-telegraphs, published late in 1897, came into our hands; and the last few months of the year witnessed a truce to the war of "wireless-telegraphy." A wave of good feeling has now united the opponents into something like coherence, and the honors have been divided with universal approval. The result is that for the future Italy takes prominence, England eminence, while Russia, Germany, and France share the luxury of many grievances.

The close of the year is very appropriately characterized by three papers, respectively communicated by Dr. Lodge, Mr. W. H. Preece, and Mr. S. Evershed, to the Institution of Electrical Engineers, all emphasizing the merits of one and the same system of space telegraphy. The authors themselves were more or less unanimous as to the course further experiment should take, but the discussion that followed the reading of these papers showed a certain lack of directness; many of the speakers were carried away by side issues, and a great deal of time was occupied with ill-considered suggestions and old matter. While fully recognizing the value of open discussion, and of hints thrown out at random on subsidiary matters, the present writer thinks it may be useful here to indicate the limits to which the problem may be narrowed down, and to point out the very serious work that is now calling for the aid of space-telegraphy.

It is very generally admitted that space-telegraphy will replace metallic-circuit systems only under conditions where metallic circuits are impracticable. The fact that metallic circuits have been laid over the Andes may be taken as proof that there are remarkably few land-areas that cannot be spanned by wires. For communication between fixed points on rough coasts, a wire suitably protected is still the right and the best thing, as is evidenced by the cable laid in 1890 between Pollagill Bay, on the northwest coast of Ireland, and Portdown Bay, Tory Island, and thence by duplicate underground cables to the lighthouse on the north side of the island. The great advantage of a metallic-circuit system is the consequent privacy of the messages, the simplicity of the apparatus, the speed of transmission, and the possibility the system offers for working by telephone, and in other ways avoiding the expense of skilled operators. Space-telegraphy is at present limited to comparatively short distances, and its usefulness is confined to spanning estuaries, skirting seaboards, and for such purposes as that to which it was applied by Mr. Preece between Oban and Mull in 1895. But, except in rare instances, it is only likely to replace submarine cables between moored vessels and the shore, e. g. between light-ships and the coastguard stations. The point of failure in submarine-cable communication thus happens to coincide with the point of favor of space-telegraphy. The present object of those working at space-telegraphy should therefore be to supplement the cable system of coast telegraphs, so that all the light-vessels and lighthouses of our coasts may be brought into communication with one another and with the life-boat stations.

Some idea of the scope of the work of completing our coast-telegraphs may be gathered from the fact that the whole number of distinctive lights, including port, harbor, and pier lights, light-vessels, and lighthouses on the coasts of the United Kingdom in October, 1898, was 1,095, and at the beginning of that year only 51 light-vessels and light-ships were in communication with the telegraphic system. Three additional lighthouses, i. e. those at Godrevy, the Skerries, and Walney Island, were connected to the shore during last summer; but pending further results of the experiments with the system of "wireless-telegraphy," it was thought better to postpone the work of connecting more light-ships to the shore by electric cables. These lighthouses and other sea-marks are maintained out of the fund derived from lighthouse tolls, which amount to over £500,000, the lighthouses, etc., being thus self-supporting. This fund has lately been augmented by a special grant, with a view to increasing the efficiency of the system.

The hard task of establishing communication with a light-ship moored in a tide-way, successively rising and falling at each tide, swinging, rolling, and pitching, and in other ways gesticulating around her uncertain anchorage, has taxed the resources of cable engineers for the last quarter of a century. The system now generally adopted consists in the use of a swivel or toggle having a hollow spindle so as to allow a telegraph-cable to be passed up through the middle of it. This swivel is placed between the ship and her moorings at about the water-line. One or more chains lead down from "eyes" on the swivel to the mooring anchors; there are generally two such chains, or there may be three, spread out tripod-fashion, to terminate in mushroom anchors. A riding chain leads upward from the swivel, and is secured to the vessel in the ordinary manner after passing through the hawsepipe. The cable is hauled on board through the hollow swivel, over a sheave and onto a drum, which can be turned round by hand as required, to take the twists or "turns" out of the cable as they are formed. A special veering-drum has been designed by Mr. Benest, by means of which this operation of taking out "turns" is performed automatically by a special gear on the drum. Electrical communication is maintained through the axes of the drum by brush contacts or otherwise. In rough weather the riding-chain is generally veered out, sometimes up to fifty or sixty fathoms; and after a gale it is often found in tangled masses, which are sometimes as large in girth as that of a man. The cable itself, if it has not been entangled, has meanwhile been saved from kinking by the swivel device, but it suffers a good deal from the thrashing and flattening against the bottom, from friction at the swivel, and occasionally from fouling the chains. An ingenious type of veering-cable has been designed by Mr. F. C. Crawford, which is built up in such a way that it is very difficult to make a kink in it. To secure this result, the stranded conductor of seven tinned copper wires is covered with India-rubber and lapped with cotton tape to make a bedding for the sheathing wires. The sheathing consists of twelve double-tinned steel wires, each coated separately with India-rubber and tape. Finally there is an outer serving of India-rubber, which incloses everything into a compact form, and, while allowing the requisite amount of flexibility,* prevents the sheathing wires from slipping over one another when the cable is bent. As a further protection, especially against the "thrashing" action, this veering-cable is occasionally threaded with beads or ferrules of lignum vitæ, or with washers of India-rubber.

Another metallic-circuit method has been tried at Sandy Hook,† in which use is made of the mooring chains themselves as a means of connecting a telephone in circuit from the vessel to the cable. This method is reported upon very favorably by its designers, Messrs. Blake and Caldwell, but in their account of it the conditions are not very fully elaborated. The present writer made some experiments in this direction some years ago, and came to the conclusion that the conductivity of such chains was too variable to be trusted. His tests showed that a mooring-chain of 2-inch links and ½-inch iron, twelve fathoms in length, after being pickled in tar, dried, and slung up in the air, had a resistance of 9 megohms when tested with 100 volts; when tested with 750 volts the resistance broke down to 400 ohms. A similar chain, dry and somewhat rusty, had a resistance of 850 megohms. When dipped in water and again slung up, the resistance of the 12 fathoms was 25,000 ohms. Chains sagging in water were able to transmit telephone currents with a battery of a few volts. Two mooring-chains, of the same dimensions as those described above, were carefully tarred, and the contacts at the links were cleaned bright over a small area. The chains were then paid out from the shore parallel to one another, 8 feet apart, in about two fathoms of water in the Thames, the distant ends being hauled on to a barge. Telephoning between the barge and the shore was impossible, even with 100 volts in the circuit. All the electricity passed from chain to chain by way of the water. Brass chains had, of course, much lower resistance than the iron chains; the resistance of brass chains was practically the same, wet or dry. But it was always found that with any chain whatever in the circuit, the loose contacts caused "buzzing" in the telephone. It is possible that Messrs. Blake and Caldwell used chains under great stress, or that they used some special device, but in view of his own experiments the present writer does not regard the chain system as a practicable one.

Some years ago an alternative method of connecting a light-ship to a telegraph cable was suggested by Mr. James Wimshurst. He arranged a swivel which contained two flat coils, a primary and a secondary, placed one over the other, so that one could rotate coaxially upon the other, for the purpose of avoiding kinks as the ship swings about. As a matter of fact, the danger does not depend so much upon the twist as upon the thrashing action due to the rise and fall of the cable. Mr. Wimshurst's suggestion is worthy of a trial, but it must be remembered that the swivel, in the form proposed by its designer, meets only a very small part of the difficulty.

The short review of metallic-circuit and allied direct-cable methods serves to show that the attempts made in this regard by the Royal Commission have only resulted in partial success. While admitting that the problem is now fair game for the space-telegraphers, the present writer would point out that the resources of cable engineers in devising direct metallic-circuits are by no means exhausted. There is a singular lack of evidence on this point in the Blue Book; the Royal Commission seems to have swung about a good deal on its own small swivel, with something very like disregard for outsiders. For some reason, perhaps unknown, they failed to call as witnesses the very men whose experience would have made for success. In departing from these older methods, it must not be forgotten that we are departing from all the advantages offered by the telephone; skilled operators will have to be requisitioned, and there will be need for a delicate device for "calling up" the operator.

The fourth report (dated May 12, 1896) of the Royal Commission concluded with a very hopeful note on a contemplated trial of an "inductive method" suggested by Mr. Evershed. "Under this system," it says, "the cable running from the shore is laid in a circle on the bottom of the sea immediately under the light-vessel, the circle having such an area that the vessel will always be within the circumference of it. Round the deck of the vessel a number of 'turns' of insulated wire are coiled, which are in connection with a telephonic receiver on board ship. This system has not yet (May, 1896) been subjected to a practical test at a light-ship."

The fifth and final report of that same Royal Commission (September, 1897), referring to the trial, observes that "the experiment was carried out in August, 1896, at the Goodwin (North Sand Head) light-vessel, but after a careful trial it proved a failure. The apparatus had been tested on shore with satisfactory results, but when it was tried at the light-vessel, which is moored in ten fathoms of water, it was found almost impossible to effect communication by means of it, the electric energy being almost entirely lost in the sea. The difficulties experienced were entirely electrical."

In the following year a mathematical investigation as to the cause of this failure was undertaken by Mr. C. S. Whitehead (Proc. Phys. Soc., vol. xv., pt. xi., pp. 188–200, 1897); it was communicated to the Physical Society in a paper read June 11, 1897. His theoretical results show that if his calculations are correct, the normal magnetic induction of the primary coil loses 79 per cent. of its initial value in passing to the secondary through ten fathoms of sea-water. These figures as to the absorption-factor of sea-water have been criticised by Mr. Oliver Heaviside and by Dr. Oliver Lodge. In the meantime Mr. Evershed has turned his attention to improving his apparatus. In his recent paper he regards the inductive coils as a particular case of a dynamo-electric machine, he neglects the absorption-factor, and gives an expression for the power available at the receiving station for ultimate conversion into motion at the receiving instrument. The result arrived at is that the mechanical power is independent of the number of turns into which the total volumes of copper are divided on the primary and secondary circuits, and that the two circuits should have equal volumes of copper. His assumption at the outset, that the use of two horizontal circuits implies a loss of one-half the mutual induction between them, may have to be modified. Perhaps the most important part of Mr. Evershed's paper is his description of a "call" or receiving apparatus, which enables exceedingly minute currents to be detected. From a remark in his paper, he does not appear to be aware of the work that has been done in America by Lucien Blake and Eugene Caldwell in their attempts to provide an instrument to replace the telephone. In the annual report of the light-house board of the United States (June 30, 1895, p. 37) will be found an account of a calling device. This report says: "The receiving apparatus or relay for this system would be vibratory in character and tuned to a frequency of vibration to correspond with the period of the calling current. In addition to this mechanical adjustment, the electrical circuits might be adapted by the use of condensers and inductances to respond more readily to alternate currents of the same period. The action of such a system would be cumulative, i.e., each successive impulse of current would arrive just in time to increase the vibration in the relay until sufficient amplitude would be obtained to operate a circuit-closing device." This report also touches upon an interesting point raised by Sir Henry Mance in the recent discussion. With regard to the sensitiveness of "calls," it observes that "a careful study of all kinds of instruments in which weak alternating currents produce mechanical movement, shows that by far the most efficient are those in which the current does not produce an alternating magnetic field, as in the electrodynamometer, but operates to increase and decrease the strength of field of a permanent magnet. The mechanical motion produced by such polarized machines is always vibratory. Careful measurements in the laboratory show that this relay will work positively with a current representing 0·0001 watt, and that it can be operated with much less energy than this." This report seems to have escaped the attention of Mr. Evershed; he suggested in his recent paper that so far as he was aware the ordinary Bell telephone has been exclusively used as the receiving device in this class of experiments. There is, of course, no question as to priority; Mr. Evershed was using a vibratory indicator on this synchronous principle in 1892, the American report refers to an instrument designed in 1895. In his latest (1896) form of apparatus, Mr. Evershed duplicates the vibratory metallic rectangles; they are connected to two separate secondary circuits in such a direction that they oscillate in opposite phases in a strong magnetic field. This arrangement has the advantage that when the twin rectangles are in unison it is almost impossible to bring them into contact by shaking the instrument.

* This cable is in use at Formby Light-ship, with very satisfactory results.

† Annual Report of the Lighthouse Board of the United States, June 30, 1895.

Mr. Preece's paper is a history of the experiments made by himself and his staff, since 1885, on "the electromagnetic form of ætheric telegraphy," i. e., on the method of signaling between one alternate current circuit and another. This work has been more or less familiarized to us by the newspapers. He used horizontal coils of large diameter at the sending and receiving stations, but they were regarded as "impractical things," and they were replaced by straight conductors, placed in parallel planes, one at each station. Capacity and self-induction were eliminated. An interesting series of experiments is described, in which two earth plates are buried at a distance apart in the earth; the lines of electric "flow" are traced, and the locus of a hypothetical resultant conductor is plotted. Incidentally, Mr. Preece makes the curious statement that "we know by Ohm's law that the resistance of a circuit increases with its specific resistance and length, and diminishes with its sectional area." By Boyle's law this involves a misconception! Of the various arrangements of inductors for his mode of signaling, Mr. Preece prefers parallel wires connected to earth at each extremity, the wires being carried to a considerable height. The most satisfactory results were obtained over a distance of 3·3 miles across the Bristol Channel; and when it is remembered that the speed of signaling is practically as high, and that the system is as certain and as efficient as the ordinary metallic circuit system, this result must be regarded as the best so far brought to notice.

The question naturally occurs to us at this point, What then has become of the "coherer" systems? Mr. Preece has recently said that the Marconi system is able to traverse a distance of twenty-five miles; but on the same occasion he mentioned that there would be no difficulty in communicating by the alternating current inductor system over a similar distance. Hence there is little to choose on the merit of distance. On the other hand the speed of signaling by the Marconi system is limited to something like twelve words a minute, and we must conclude that it is this circumstance that handicaps the method. It is also probable that "coherer" systems are at present too susceptible to mechanical and fortuitous electrical tremors for the ordeal of a telegraph office, but in the absence of evidence it is perhaps scarcely fair to draw comparisons in this regard. According to The Times of Monday, January 9, arrangements are being made under the direction of Signor Marconi at the South Foreland lighthouse, and aboard the South Goodwin lightship, for a series of experiments with his apparatus. It is stated that if the system is found satisfactory it will forthwith be adopted between those points—the distance between them is about three miles.

Two articles in The Electrician of November 12, 1897, one by Dr. Lodge * and the other by Mr. A. C. Brown, should be referred to as indicating the extent of the work done and the hopefulness of the votaries of "coherer" systems at that time. Later developments of the "coherer" system, particularly in the matter of syntony and the best arrangements of contacts, are dealt with by Dr. Lodge in a communication to the Physical Society of January 21, 1898, an account of which appeared in Nature in February, 1898. The possibility of individualizing signals by syntony on Dr. Lodge's system is discussed in an excellent article in The Electrical Review of August 19, 1898, which is prefaced by some remarks that already show the weak points of "coherer" systems. Messages had then been sent by Marconi over a distance of about sixteen miles, and received in "dot and dash" on the Morse ribbon at a rate of something under twelve words a minute; but it had been found in practice that the principle of resonance could not be applied with sufficient effect to insure that messages should be recorded only by a single selected receiver. Whether the later more elaborate methods of syntony for "coherer" systems, proposed by Dr. Lodge, have justified themselves in practice is not yet known, but it is a significant fact that Dr. Lodge's most recent paper on the subject of space telegraphy makes a distinct departure from the "coherer" system, and contains no account of experiments in the direction of syntonized receivers used in this particular way.

In 1898 experiments as to the mysterious connection between "coherers" and photo-electric phenomena made little progress toward a practical system of telegraphy. In the hands of Prof. Minchin these experiments, at the outset, showed great promise; they gave us the "collecting wire" which, protruding into space, acts as a "feeler" for Hertz waves, but at present they remain as toys of the laboratory. The so-called "Lichtelektrische Telegraphie" of Prof. Zickler, of which a very good account is given in the Elektrotechnische Rundschau, No. 21, pp. 232–233, 1898, is more pretentious as a means of signaling. Prof. Zickler makes use of an old discovery, due to Hertz, that ultra violet light is able to reduce the spark resisting power of an air-gap. He directs a beam of light from an arc lamp provided with a shutter, upon the extended spark gap of an induction coil, and by opening and closing the shutter causes sparks to pass at the gap at corresponding intervals of time. These sparks affect a "coherer" circuit, and signaling is rendered possible. Such experiments are very attractive from a purely scientific standpoint, but it is not easy to see the advantage of this method as compared to the ordinary heliograph. Using the simplest form of apparatus, Prof. Zickler succeeded in signaling by this means across a space of two meters; and by the aid of an arc lamp that expended nearly two horse power, and by the use of quartz lenses, that distance was extended to 200 meters. The speed of receiving the signals is not mentioned; the extreme limit is probably about twelve words a minute. He proposes to apply the system to lighthouses and to fortresses. We admit that such a system would be admirably suited for the purpose of warning our foes off dangerous parts of the British coasts; but for the purpose of warning our own or friendly ships, a surer means of communication must be adopted.

Comparing the various methods, and keeping in mind that we are here concerned with a practical question for engineers, rather than with the scientific aspect of space-telegraphy, it would seem that the "coherer" systems as a whole are about to be cast aside, and that preference is to be given to alternate current inductor systems for coast telegraphs. If this is indeed to be the case, the problem is greatly simplified, and experiment resolves itself into the single task of finding the best design of apparatus for communicating between a moored light-ship and the shore by means of inductor coils. Dr. Lodge's paper on "Improvements in Magnetic Space-Telegraphy" gives us what may be regarded as the academical aspect of that task: he describes a new receiving device for magnetic induction telegraphy, and he explains the method of putting it into practice. The principal feature of this device is the outcome of an electric resonance experiment first described in Nature, vol. xli., p. 368, eight years ago—namely, the experiment of syntonic Leyden jars. Dr. Lodge now replaces the jars by condensers, and the "tuned circuits" take the form of horizontal coils of wire. The inducing coil is connected to an alternate current dynamo, and the induced coil is connected to a train of telephone relays, the last of which is thus set into violent action at each received impulse. The paper includes the theory of two such circuits arranged in mutual syntony, and it is full of information and suggestions as to the proper course future experiment should take; the advantage of syntony is discussed, and the relative importance of conduction and induction is considered, together with a detailed investigation of the theory of "detectors" for such a system.

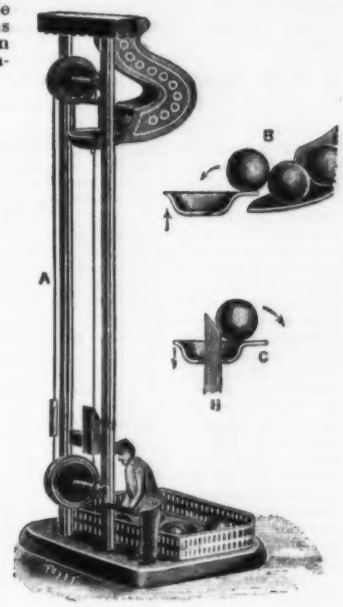
The absorption factor in the case of sea water will probably be one of the first matters to be dealt with by experiment and theory in the present year. By the use of horizontal inductor coils, one on the lightship and one ashore, Dr. Lodge avoids the practical difficulty: nevertheless the problem is sure to elicit his interest. Mr. Whitehead, holding tacitly to Maxwell's equations, deduces a law for the absorption factor, and to this law Dr. Lodge takes exception. Maxwell supposed that the total current was made up of the polarization current and the induction current: Mr. Whitehead assumes that the polarization current may be neglected, and that, provided the frequency is not comparable with that of light, no serious error can arise from that assumption. Do Maxwell's equations fail then for such a case? Dr. Lodge seemed unwilling to admit that they do fail; he suggested that Mr. Whitehead had written them down in a form that did not agree with Maxwell, and that Prof. J. J. Thomson had written them in another form. Mr. Whitehead now asks Dr. Lodge what is the right form. And that's how the matter stands.—ROLLO APPLEYARD in Nature.

* By a slight error, Dr. Lodge there attributes an experiment on liquid "coherers" to Lord Rayleigh. This experiment was first described and shown by the present writer on March 26, 1897, at the Physical Society. A few weeks later it was repeated by Lord Rayleigh at the Royal Institution.

SOME NEW MECHANICAL TOYS.

ALTHOUGH manufacturers have in recent years produced some marvels in the way of mechanical toys, they do not seem to have brought out anything very striking in this line for the holiday season that has just passed. Of a few that seem worthy of notice, we reproduce figures and descriptions from our contemporaries L'Illustration and Le Monde Illustré.

THE PUMP.



THE WINDLASS.

The Little Bootblack.—The motion of this toy is produced by an escapement anchor actuated by a ratchet wheel. The rod that takes the place of the bones of the human arm is moved from left to right whenever a tooth of the ratchet wheel acts at its upper extremity. Like the arm of the figure, this rod is bent and carries at its lower extremity a counterpoise concealed in the brush. As soon as the contact ceases between the tooth of the ratchet wheel and the top of the rod, the arm is carried back to its former position under the action of the counterpoise until another tooth actuates the rod. In this way a regular to and fro motion is obtained.

The apparatus is wound up by means of a key arranged to this effect. During the operation an action is exerted upon a toothed wheel that meshes with a pinion of which the axis displaces the ratchet wheel. In measure as this wheel revolves, it effects a pressure upon a spring. When such pressure becomes adequate, there is nothing further to be done but release the key. The spring, upon relaxing, causes the ratchet wheel to revolve in the contrary direction, and the little bootblack begins brushing away in a lively manner.

THE LITTLE BOOTBLACK.

The Windlass.—In this toy, two pulleys around which winds a string are placed at the extremities of a couple of uprights. On the one hand, the string is connected with a counterpoise and, on the other, with a car in the form of a spoon.

At the top of the uprights there is arranged a loading device which is filled with balls. The descent of the car is arrested by a stop placed at the foot of the uprights. In its normal position the car is held near the loader, since its weight is less than that of the counterpoise. If the latter be raised to the upper extremity of its travel and be left to itself, it will redescend by virtue of its own weight, and consequently cause the car to move in the contrary direction. But, by reason of the velocity acquired, a shock then occurs between the car and one of the balls of the loader, and causes the ball to drop into the car. At this moment, the weight of the ball being added to that of the car, the counterpoise becomes lighter than the latter and consequently ascends. The car, on the contrary, descends until it meets with the stop at the bottom. Now the upper extremities of the two plates that form the stop are not in the same horizontal plane, the lower one being directed toward a cage of which the bottom is provided with apertures. The violence of the shock throws the ball out of the car into the cage, where it nestles in one of the holes in the bottom. The car, eased of the weight of the ball, is then raised again by the counterpoise, receives another ball, redescends, strikes the stop, and continues the operation until all the balls have been thrown into the cage.

THE PLANTER.

All that now remains to be done is to add up the figures marked alongside of the apertures into which the balls have rolled. The winner will naturally be the one who has obtained the largest total.

Upon the whole, after the first impulse has been given, the windlass works automatically, so long as there are any balls left in the loader. In order to complete the illusion, the axle of the lower pulley is provided with a winch to which are attached the two

hands of the tin figure of a man who seemingly produces all the motions that, in fact, effect his own.

The Pump.—This toy, which is made wholly of tin, consists of a pump to the handle of which are jointed the hands of a figure in bicycle costume. The motive power consists of a piece of rubber which is twisted by means of a small winch. The water rises through a tube from a reservoir at the bottom, pours into a basin, and from this runs out again and falls into the reservoir to be used anew.

The Planter.—This toy represents an East Indian planter who rocks backward and forward in a rocking chair, smokes, turns his head, bows, moves his eyes, opens his mouth, and emits a puff of smoke, raises his left arm to bring his paper before his face, and then smokes again. This automatic smoker is very ingeniously constructed, with concealed apparatus which causes the figure to inhale smoke and then expel it in blue curls.

A NEW WAY OF CONSTRUCTING STEAM-BOILER FURNACES.

A NOVEL steam-boiler has recently been introduced by James Beggs & Company, of 9 Dey Street, New York city, which presents certain improvements in the manner of constructing the furnace-walls.

The side walls of the furnace are composed of removable iron plates and of notched fire-bricks. The space between the bricks and the plates is filled by a refractory lining consisting of an asbestos composition. The lowermost course of bricks rests upon the inclined upper face of a casting, whereby the walls are given an inclination which prevents the bricks' gravitating inwardly. The upper courses of bricks are so placed upon the lowermost course that the notches in the bricks will coincide and form cylindrical recesses for the reception of locking keys or tubes. These locking tubes, at their projecting ends, are provided with nuts, by means of which the bricks can be more tightly bound together whenever it may be necessary. As the lower courses of bricks in the furnace-walls are destroyed earlier than the upper courses, a time is necessarily reached when new bricks must be substituted for those which have been burnt out. When such repairs are necessary, the uninjured upper courses can be retained in their positions by means of the locking-keys, and it is necessary to remove only the lower courses in order to make the necessary repairs.

The front wall of the furnace immediately above the fire-door is composed of arch-bricks, the lower edges of which are in contact with a flange on the fire-door. At each side the arch abuts against a bolted angle-plate. Through one of the angle-plates screws pass, which can be adjusted to press against an intermediate plate in order to take up any looseness in the bricks.

The dead-plate is mounted in the usual manner at the bottom of the door-opening, but differs from most similar plates in having its back edge provided with deep notches rounded at the bottom. The notches allow the back edge to expand under the high temperature to which the plate is subjected. By reason of the rounded bottoms, the liability of the plate's cracking is reduced.

BORING, THREADING, AND COUNTERSINKING MACHINE.

FOR the working of large steel cylinders open at but one extremity and combined in twos, threes, or more, in one body in common, Messrs. Droop and Rein, of Bielefeld, have been led to devise and construct a powerful machine tool, which we illustrate herewith from the Revue Industrielle.

By reason of the particular conditions which this tool has to satisfy, it has been necessary to deviate considerably from the arrangements usually employed for the boring tool and the mechanism that sets it in play. The weight and dimensions of its movable parts, moreover, far exceed the limits admitted in machines of this kind, and so the general arrangements of this tool present interesting peculiarities.

FIG. 1.—BORING, THREADING, AND COUNTERSINKING MACHINE.

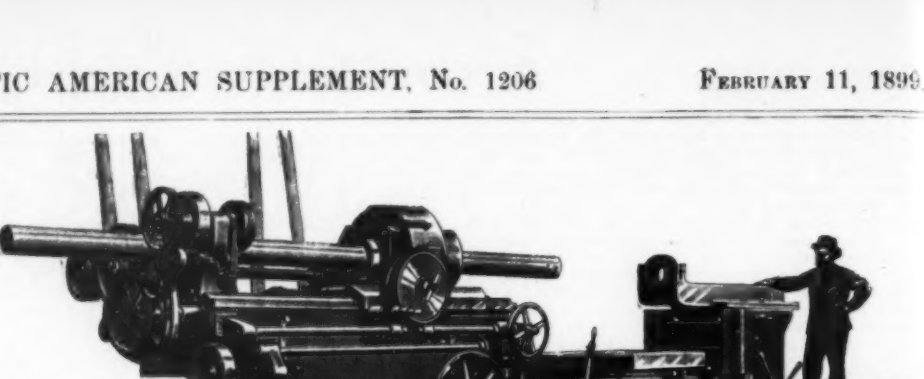


FIG. 2.—TRANSVERSE SECTION THROUGH THE CARRIAGE UPON WHICH THE WORK RESTS.

When it concerns cylinders closed at one extremity only, the boring bar constitutes the support of the tool, which thus works projectingly. It is a strong cylindrical rod of crucible steel that carries a groove throughout its entire length, and presents a uniform diameter from one end to the other.

This rod is screwed in front into a mandrel prolonged by a long socket which forms a hollow shaft that revolves in the bearings of a carriage and carries a toothed wheel. The loosening of the mandrel key permits of regulating at will the initial projection of the bar according to the depth or distance of the cylinder to be bored.

Besides the support afforded the bar by the carriage, it is held by a sleeve adjusted in the bearings of a stationary puppet and forming a device that intervenes in the transmission of the motion to the accessory mechanisms of the machine. The bar, in fact, communicates its rotary motion through the key and the groove.

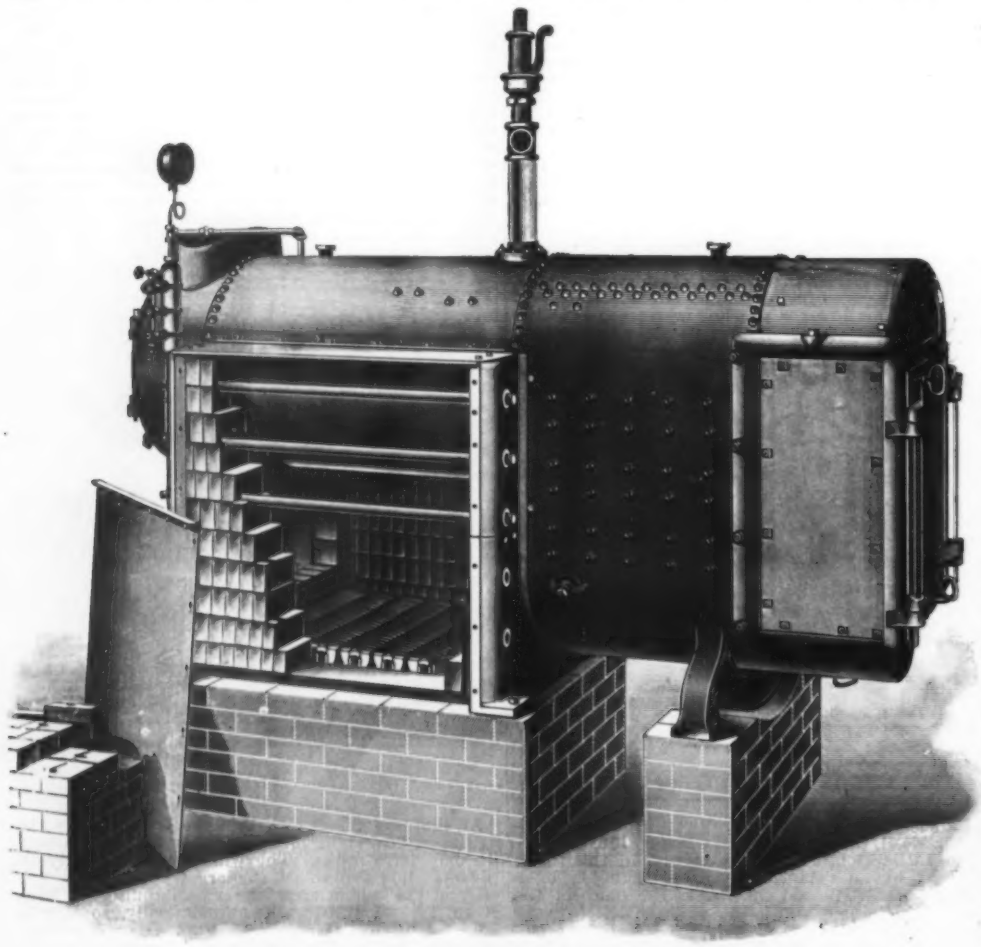
Spare bars of diameters up to 7 inches are placed at the disposal of the operator, who employs the one best adapted to the diameter of the hole to be bored. To this effect, each of the bars is accompanied with a set of interchangeable joints adaptable to the sleeves of the carriage and puppet.

The machine is actuated through a five-speed cone combined with a triple train of toothed wheels which transmit motion to a longitudinal shaft grooved throughout its entire length. This latter actuates the drill bar through the intermedium of a spur gear borne by the carriage and following the latter's motions.

With a pinion is connected an engaging and disengaging coupling of which the lever permits of arresting at once, by hand, the rotary motion of the drill bar and the advance that depends thereupon. The object of this arrangement is to stop the tool at any definite point of its travel, after screw threads have been formed in the cylinders operated upon. For this kind of work, the carriage that carries the drill bar is provided with a screw that is set in operation by a train of gear wheels actuated by a toothed wheel keyed upon the sleeve of a puppet and combined with wheels mounted upon a double support. The nut of this screw may be opened or closed at will by means of an arrangement actuated by a winch.

As for the forward motion of the carriage in the ordinary work of boring, that is determined by a rack with oblique teeth over which moves a pinion fixed to a transverse shaft connected with the carriage. This shaft carries in front two equal cogwheels, one of which actuates the other through a coupling easily thrown into and out of gear, and meshes with a pinion having helicoidal teeth and carried along by the grooved shaft.

The two forward motions for threading and boring may, moreover, be reversed by means of an interposed



AN IMPROVED STEAM-BOILER FURNACE.

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pinion, as in the system employed in ordinary lathes. It is possible also to move the carriage forward by hand upon its rack by actuating the shaft through one of the two equal wheels (above mentioned) disconnected from the helicoidal toothing and set in rotation through a pinion of which the axis carries a winch. In threading, the desired variations in the pitch are obtained by changing the wheels of the train at the top of the double support.

The grooved shaft upon which the pinion of the wheel slides is actuated by the neighboring shaft, an endless screw gearing, and a pair of bevel wheels. This last mentioned shaft is actuated directly by a belt that connects one of the pulleys of the puppet and the pulley of a short shaft that carries three pairs of spur wheels that give the shaft so many different velocities. A longitudinal key maneuvered by a lever permits of rendering interdependent, at will, either one of the two wheels and their common axis. So, too, the two shafts may be coupled or disconnected, as need may be, by means of a coupling clutch combined with the pinion and maneuvered through a handwheel.

The table upon which the piece to be worked rests is supported by a crosspiece guided by uprights in front of and behind the frame. This crosspiece carries at each of its extremities a pair of nuts that engage with vertical screws that serve to raise and lower it automatically. To this effect, the upright of the puppet carries, on the belt side, a short horizontal shaft actuated by a pulley that directly actuates the shafting of the shop, and, through a bevel wheel, communicates its motion to the vertical shaft, which acts upon the longitudinal shaft in the vicinity of the foot of the machine. This shaft, in turn, through bevel pinions, transmits rotary motion to the transverse shafts upon which are keyed the helicoidal pinions of the wheels that actuate the vertical screws already mentioned.

A large handwheel in front of the upright of the puppet permits of accurately regulating by hand the position of the crosspiece of the table in a vertical direction. Through a bevel wheel, it sets in operation the vertical shaft previously disconnected from the train of the pulley through a gearing of which the lever traverses the upright of the puppet so as to come within reach of the operator.

The table may also be quickly displaced automatically in a direction parallel with the boring tool. In fact, the prolongation of the shaft of the pulley acts, through bevel wheels and a helicoidal gearing, upon a vertical shaft arranged between the upright screws and actuating, likewise through bevel wheels, the longitudinal screw of the carriage that moves upon the crosspiece.

An engaging and disengaging gear actuated by a lever permits of coupling with the screw either the mechanical control of the shaft or a bevel gearing dependent upon the transverse shaft, which is maneuvered with a ratchet lever in order to bring the carriage to the precise position that it ought to occupy.

Upon the longitudinal carriage of the crosspiece is mounted a transverse carriage to which, for countersinking, may be given automatically a motion, according to its direction, by means of the nut of a screw controlled by spur pinions, an intermediate shaft, and a helicoidal gearing of which the endless screw slides upon the grooved shaft.

This latter receives its motion from a pair of bevel pinions that follow the vertical motions of the cross piece of the table and revolve under the action of the grooved shaft, which is finally set in operation, by means of a train of spur and bevel pinions, through the main shaft.

Finally, upon the transverse carriage is mounted a rotary plate provided with internal toothing that meshes with a pinion actuated by a helicoidal gearing and a rod carrying a handwheel. This arrangement permits of bringing in succession pieces at right angles with each other, with a view to executing operations in each direction with a single mounting. The diameter of this plate is 5¾ feet, and its frame, inclusive of all the mountings, weighs no less than six tons.

It is unnecessary to say that this machine may be employed for the boring and countersinking of all sorts of large pieces, and this is why there is arranged upon the upright to the right of the frame a carriage provided with an opening into which pass the long boring tools.

As may be seen from the figure, the greater part of the machine is placed beneath the surface, and the tool is thus about 4 feet above the level of the floor. At such a height, the work is easily superintended and the machine easily operated. The whole machine is no less than 23 feet in length and weighs about 26 tons.

THE PARIS METROPOLITAN UNDERGROUND RAILROAD.

WORK has now begun on the new Metropolitan Railway in Paris, says The Electrical Engineer, and the contract for the entire equipment has been awarded to the Westinghouse Electric Company. The system consists of six lines. 1. From the Porte de Vincennes to the Porte Dauphine. 2. Circular line by the external boulevards. 3. From the Porte Maillot to Menilmontant. 4. From the Porte Clignancourt to the Porte d'Orleans. 5. From the Boulevard de Strasbourg to the Pont d'Austerlitz. 6. From the Cours de Vincennes to the Place d'Italie, by way of the Pont de Bercy.

The maximum width of the rolling stock is fixed at 2·4 meters. The city of Paris was empowered to borrow the sum of 165,000,000 francs, the estimated cost of the construction. The work of constructing the line No. 1 and part of lines Nos. 2 and 3 is now under way, and it is expected that they will be finished in time for the opening of the Exposition in 1900. The other lines will be built at a subsequent time. The total length of the lines will be 65 kilometers, equivalent to about 41 miles. The whole system will be double tracked. The city of Paris undertakes to carry out all the subterranean work, cuts, viaducts, platforms, etc., while the operating company bears the expense of the roads leading to the station entrances and the expense of the stations. The concession is granted for a period of twenty-five years. At the expiration of this time the city becomes surrogate to all the rights of the company and the roadbed and its accessories, especially the electric power house. The city reserves to itself the right to acquire the material and the equipment of the stations, workshops, offices, fixtures, etc., and entrances to stations at an appraised valuation and will have the right to acquire the entire system by purchase after May 31, 1910. The rates of fare for the metropolitan district will be first class, five cents; second class, three cents.

VERTICAL COMPOUND ENGINE.

THE engine illustrated was constructed by the Anderston Foundry Company, Limited, of Glasgow. It is of the closed double-acting type, but is designed so that it is as accessible as any ordinary open engine. The frame or case is in one strong casting with covers, back and front, extending the full width, with large hinged doors in the panels. Special arrangements are made for supplying oil to all wearing parts under pressure, while the bearings run so close as to avoid throwing oil excessively even at the highest speeds. A marked improvement is the use of an open filter into which the oil from the crankpit flows, thus preventing any dirt, bits of packing, or waste, being forced back through oil channels.

The combined bedplate for engine and dynamo forms an oil tank, and is so arranged as to separate the water from the oil as far as possible, while the last oil to flow from the crankpit is the last to return to the engine. Provision is also made for supplying oil to all parts from an ordinary standpipe and oil box.

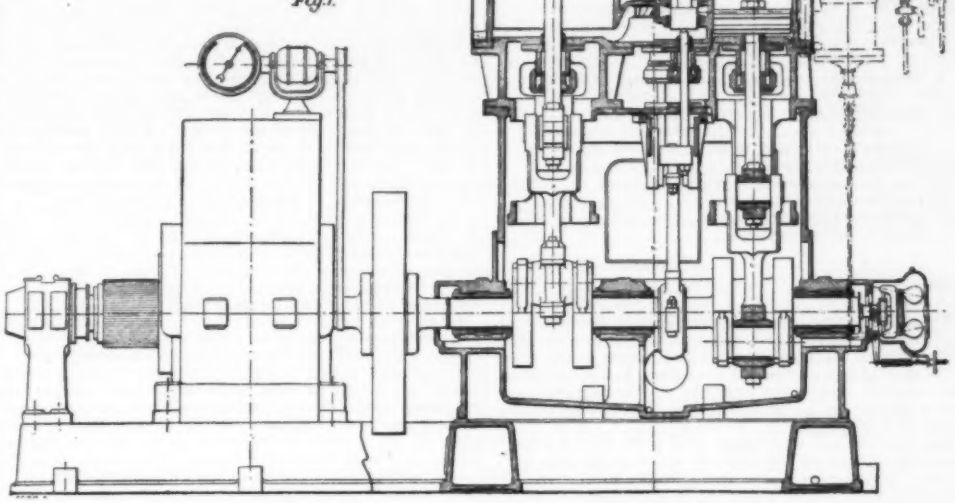
The steam to the cylinders is regulated by independent valves, each proportioned for its own cylinder, and wrought from one eccentric. The stuffing glands are all outside the main case, and can be adjusted while at work and locked to prevent working back. The governor is fitted direct to the crankshaft. It has only one spring to the balls, and this spring can be adjusted while at work. We are informed that in many cases the governor controls the speed within a variation of one per cent. between full and no load.

The steam drier is also of novel construction; it is placed directly over the governor valve and effectively prevents water getting into the cylinders when the engine is at work. Several of these engines have been in constant use for over sixteen months, giving excellent results. They are made in all sizes, simple, compound, or triple-expansion.—Engineering.

SUPPRESSION OF SMOKE.

THE devising of practicable methods of reduction of the "smoke nuisance" has become one of the most important problems in applied science for our time, and has been a subject of experiment and of legislation for many years past, says Science. Of late, some success has been met with on both sides the Atlantic. In St. Louis, perhaps, as great success has been attained as in any city in the United States, through the public-spirited co-operation of the city government, the Board of Trade, and the scientific men and leading engineers of the place; but there remains much to be done and investigations are still in progress, some of which are important. Recent discussions at Philadelphia, under the auspices of the Franklin Institute,* have thrown much light upon the subject and have afforded many valuable facts and data.

Fig. 1.



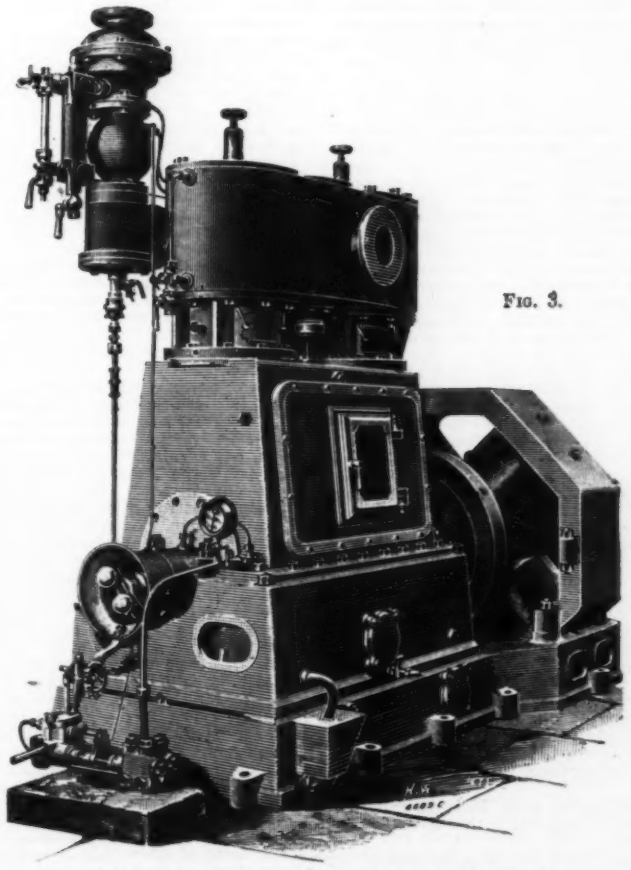


FIG. 3.

VERTICAL COMPOUND ENGINE AND DYNAMO.

* Journal Franklin Institute, June, 1897.

We have now the published results of another and formal investigation by a commission, organized at Paris, composed of MM. Huet, Brull, Hirsch, Humblot, Lamouroux, Michel-Levy, and DeTavernier, all holding important positions in the municipal administration, or in the great schools of mines and engineering, or as leading members of the Society of Civil Engineers. The commission was in session, at intervals, from June, 1894, to October, 1897. It made a study of reports and documents bearing upon the subject, conducted important experiments, reduced them to order and studied out definite conclusions, and also investigated the origin, state, and the progress of the art, completing its report at the last-named date. This document of over 150 pages, large 8vo, with 25 plates, is now in process of distribution.*

Although more or less attention had been given the subject by the municipal government for years, nothing had been accomplished, and it was, in this instance, proposed to organize a technical commission to conduct competitive tests of various methods and apparatus having for their object the suppression of smoke from boiler furnaces. The above-named commission was accordingly formed and was assigned a credit of 8,050 francs for expenses. The commission was to select acceptable forms of furnace and report to the city government for their license and use. One hundred and ten competitors appeared, their schemes including the following:

GENERAL PLAN OF PROCEDURE.

1. Mechanical feed and methodical combustion	16
2. Supplementary injection of air, hot or cold	20
3. Injection of steam, with or without air	5
4. Stirring the gases	7
5. Gas producers and heating the gases	7
6. Combustion of dust fuel	2
7. Washing the smoke	16
8. Various other systems	37
	110

Of the total, three-fourths were French devices, one-fifth English, three American, and the others of various European nationalities. A preliminary study led to the careful test of ten. These were tested to ascertain whether they were capable of burning ordinary fuels without smoke and whether they were suitable for use in steam-making.

They were tested with rapid and with slow combustion, with operatives supplied by the makers and with firemen furnished by the commission, under the direction of first the one and then the other. The intensity of the smoke was observed and noted on a scale of five points. The usual standard methods of determining the efficiency of the apparatus were employed. The corps of observation was detailed from the offices of the city administration, organized and directed by the commission.

The history of legislation, as given, traces the progress of the subject in England from the time of Charles II., who, two hundred years ago, inaugurated repressive measures. In France, this form of legislation began with an imperial decree in 1810. Both countries now have well-considered laws for suppression of smoke in cities. The technical history, curiously enough, begins with plans by Denis Papin. The next inventor to follow this illustrious man of science was James Watt, with his inverted draught and later arrangement of "dead plate." The "automatic stokers," "très usités en Amérique," are referred to and their incidental but none the less effective smoke reductions are described. Legislation now exists in all civilized countries, and many more or less effective devices and methods are in use for suppression of smoke.

A commission of distinguished engineers and scientific men was organized by the German government in 1892, which, after prolonged experimental investigation, concluded that success had not been attained, but that the way to success was clearly indicated. This commission, in computing the heating power of combustibles from analyses, adopted the formula: $8000\,C + 29000\,(H - O/8) + 2500\,S - 600\,W$; where W is moisture.

The outcome of the work of the French commission was the refusal to assign a first prize, the awarding of two second prizes, of two first mentions, and of one second mention. The conclusions formulated indicate that the commission is not satisfied that a real success has been achieved, but nevertheless the researches were not without value. Like the German commission of 1892-94, it is concluded that "the work of the commission should be considered only as a contribution to the study of 'fumivorité,' and it is to be hoped that these researches may continue. There remains much to be done, and a part of this collection of exhibits has very nearly attained the object proposed."

Among the specific conclusions are these:

Smoke cannot be suppressed without considerable excess of cost.

Special fuels, as anthracite, coke, fuel-gas, and mineral oils, may be resorted to, and with success, where cost is not objectionable.

The chimney-top should be visible to the man at the furnace.

Prolonged trials should supplement such investigations as those prosecuted by this commission, to ascertain the durability of the apparatus and of its efficiency.

Existing legislation, well enforced, is advised, rather than any specific new legislation.

The appendix to the report is an elaborate presentation of the logs, tables, and drawings of the apparatus of the trials described in the text. The whole constitutes a very valuable contribution to the literature of the subject, in the department of applied science, and deserves to be permanently preserved in every library of applied science, beside the reports of the Franklin Institute discussion.

R. H. THURSTON.

* "Concours pour la suppression des fumées produites par les foyers de chaudières à vapeur. Rapport de la Commission technique. Prefecture du Department de la Seine, Ville de Paris, République Française—Liberté, Egalité, Fraternité." n. d.

OLD TIME SUGAR MAKING IN LOUISIANA.

By Prof. H. S. MARING, S.J.

ANYONE traveling some twenty years ago along the Têche, or speeding with the first trains of the Southern Pacific through lower Louisiana, was struck by the large number of sugar plantations that were to be seen on every side. On account of the level stretches of country, the traveler beheld ever from afar the tall chimney of the sugar mill overtopping broad acres of waving cane, and on approaching nearer saw the low roofed cane sheds and the whitewashed cabins of the plantation hands. All this is now changing. It is, in fact, a thing of the past. In place of the small sugar planter, impoverished by the war and the liberation of his slaves, has come the great refinery proprietor. The latter has bought up the farms of the native creole, who was unable to keep his machinery in repair and cultivate his fields out of the meager proceeds of sugar sold at 3 cents a pound.

Before the war, and even for some time after it, when labor was cheap and sugar was eagerly bought at from 8 to 9 cents a pound at the mill, and a barrel of molasses came to $20, the sugar planter could run his mill, and, in spite of the waste necessarily accompanying open kettle sugar boiling and slow gravity separation of sugar and molasses, could live in princely style on the proceeds of a comparatively small plantation. But these methods cannot stand the present depression of the sugar market; they cannot compete with the vacuum pan and the centrifugal separator, which are now to be found in every "refinery," as the new sugar mill is called. The consequence is that the old mills are becoming fewer and fewer. As soon as their machinery gets out of repair they are left for the gnawing tooth of time to demolish them, or boilers and kettles and rollers and machines go to the junk shop as old iron. Modern improvement has driven antiquated, wasteful methods out of the field. It is another instance of "the survival of the fittest" in its true sense.

As even the memory of the old methods will be obliterated in a few years, it may be of interest to the readers of the SCIENTIFIC AMERICAN to hear something of the processes just going out of use. The data of the present paper are taken from an old mill, which ceased grinding with the past year.

Sugar making may be divided into three stages: cutting and hauling the cane, grinding or crushing it, and, lastly, clarifying and boiling the juice into sugar.

On going through a sugar plantation many a picturesque scene meets our eyes, especially during the grinding season, when all is bustle and excitement in field and mill. On every side the tall, waving canes shut in the view. Their deep, green leaves contrast pleasingly with their red stalks. They are grown in rows from 5½ to 6 feet apart. When standing, the cane with its green top is some 12 feet high; but when cut down, ready for the mill, it is rarely more than 8 feet long. As we go along we meet with different gangs of workmen, negroes for the most part, who, some 20 strong, are cutting cane under the direction of a white superintendent. One must have seen the plantation negro in all his raggedness and self-neglect to form a correct picture of these men. No two are dressed alike and hardly one has what can be called decent clothing. And withal they joke and are merry; no care sits on their brows, no sadness is in their hearts.

The cane is cut down by means of a huge knife, made of a thin blade of steel, about 18 inches long and 4 broad, with razorlike edge on one side and a hook at the end for stripping the cane of its leaves. Armed with this formidable weapon, the negro stands on his row of cane and with a slash to the right and the left, above and below, he has cleared a stalk of its leaves, has removed the green top, and severed the cane from its roots. In Louisiana sugar cane does not attain its full growth and does not ripen entirely; hence the green top has to be removed, as the juice from it would afterward seriously interfere with the granulation of the sugar.

The work of cutting cane goes on fast when the cane is straight and standing up, but when it is lying down or blown hither and thither by the wind, it is a laborious and tedious proceeding. On an average a man is able to cut about 2 tons of cane a day, and as the acre bears some 18 tons, it takes 20 men nearly half a day to cut an acre. The overseer or timekeeper is always present to notice the absence of anyone and to see that the men do their work. He himself swings a cane knife too; in fact, he has to be an adept at it if he desires the work to go forward rapidly and wishes to preserve the respect and obedience of the negroes. On the plantation spoken of in this paper, the justice of the peace of the township is the superintendent; consequently there is no difficulty experienced in keeping the hands in check.

When the cane has been cut and thrown beside every second row, cane wagons, drawn by two strong mules or more rarely by oxen, bring it to the mill, where it is dumped as close as possible to the "carrier." By the carrier is meant a movable inclined plane, 3 feet wide, made of boards held in position by a wide linked chain, which moves forward with the machinery. Four or five men are kept busy loading the cane onto the carrier, cleaning it of any remaining leaves, and cutting those canes that are too crooked to be fed between the crushers. The carrier brings the cane to a position some 5 feet in front of the rollers or crushers and some 4 feet above them, so that it can slide readily between them by means of another inclined plane. A man is stationed here, whose duty it is to see that the canes do not get jammed together and that all pass between the rollers. The rollers are heavy grooved cylinders of iron—two below and one on top—which are held so close together by strong bolts that a knife blade cannot be pushed between them, when they are not in motion. Those at the particular mill here spoken of are 3 feet in length and have a diameter of 20 inches, with a weight of from 1,000 to 1,200 pounds apiece. The lower and upper rollers, of course, revolve in opposite directions, so that the canes, once caught between them, will be pulled through entirely. The cane, as it passes between the two lower and the one upper roller, is crushed twice and when it emerges is quite dry and retains very little sugar, provided the rollers be of sufficient weight and well bolted together.

In some mills the crushed cane, or bagasse, as it is called, after having some water sprinkled on it, is passed between a second, and sometimes a third set of rollers, and is then ready for the bagasse burner. This piece of machinery for the modern sugar mill feeds the bagasse directly under the boilers, and thus saves at least half the fuel that would otherwise have to be used. There was none of this in the ante-bellum mill. Then the bagasse was used as a filling for low places on the plantation, or as a manure after having been burned in an open kiln.

The juice as it runs down the rollers is caught in a basin, and after passing through a sieve is treated to a bath of sulphur dioxide. A small brick oven has stick sulphur burning in it continually, and the products of combustion are drawn by means of a connecting flue into the juice as it flows past. Sulphur anhydride, as is well known, is an excellent bleaching agent, destroying vegetable colors readily; hence, as soon as it comes in contact with the juice, it attacks the coloring matter contained in it, forming harmless compounds, which are removed in subsequent operations. When the juice, which has at this stage a density of about 10° Baumé, has been impregnated with the sulphur fumes, it is raised by means of a small steam pump into tanks placed somewhere under the roof of the cane shed.

The next process through which the juice has to pass is clarification. This is accomplished in iron caldrons or kettles, placed in batteries of three or four, of a capacity of 300 or 400 gallons. These were formerly heated from below by a wood fire, but in somewhat modernized mills a copper steam coil supplies the required heat. When the juice has been drawn into these kettles, a gallon of milk of lime, about 20° Baumé in density, is added, and the mixture is heated, but not allowed to boil. The lime, besides checking any undue acidity in the juice, enters into combination with many of its impurities and thus cleanses or clarifies it. The heat also helps to this; for, besides other extraneous substances, the liquid expressed from the sugar cane contains much albuminous matter, which is coagulated by the heat and rises to the surface as a thick scum, carrying many other impurities with it. The foam and scum are continually removed by means of a thin board attached to a long handle.

When the juice has thus been clarified, it is drawn into a copper kettle with steam coil at the bottom and is boiled and evaporated until it reaches a concentration of 25° Baumé. When the desired consistency has been attained, the juice, which may now be called sirup, is pumped into large settling tanks, where any impurity still held in suspension is deposited. After standing for about twelve hours the concentrated juice is drawn into another copper kettle, essentially the same as the one in which it was boiled down, and is there converted into sugar and molasses. Steam is turned on and almost immediately violent ebullition takes place, which is continued until a long thermometer dipping into the boiling mass marks 234° F. When this temperature has been reached, steam is shut off and the hot sirup is transferred to a tank wagon and carted to the "coolers." By coolers are meant large wooden or iron troughs, about eight feet long, three wide, and two deep, which stand in a long row under the sugar shed. On cooling, the sugar crystallizes or granulates. The molasses, as the mother liquor from which the sugar has crystallized is called, remains mechanically mixed with it. To hasten the cooling, and therefore the granulation of the sugar, only a layer about an inch in depth is poured into the troughs at a time, and when that has solidified more is added, until the whole cooler is filled. When this has been accomplished, the mixture is transferred from the coolers to handbarrows by means of large shovels, and these again are emptied into hogsheads in which the sugar and molasses are gradually separated. To effect this, the hogsheads have holes bored in their bottoms and into these pieces of sugar cane are thrust, through which the molasses can gradually drain. The hogsheads are placed side by side on two inclined planes, and are raised somewhat from the floor by narrow strips of wood, so that the molasses flowing from them may find free passage. A wooden gutter collects the molasses and leads it to large tanks under the floor, whence it may be pumped later on for shipment. Each hogshead holds about 1,100 pounds of sugar, and 60 gallons of molasses drains from it. At first the sugar is dark brown in color, on account of the molasses still adhering to it, but when it has stood for two or three months it is a light yellow, turning almost white on top of the hogshead. It is what is known as "brown" or "muscovado" sugar.

In the process of sugar making just described a ton of cane will yield only 100 to 125 pounds of sugar, while with modern machinery as high as 180 pounds are crystallized out of the juice extracted from the same amount. Much of this difference is due to the high temperature at which sugar boiling has to be carried on in the open-kettle process. For if a solution containing cane-sugar be boiled for a long time or at a high temperature, a certain amount of the sucrose is changed into two uncrystallizable varieties of sugar, which remain in the molasses. Hence plantation molasses, as it is called, is much sweeter and more nourishing than the black refuse turned out by the "refineries," which has the last ounce of sugar boiled and squeezed out of it.

Such is a brief description of the old-time process of sugar-making. One has but to step into a modern sugar mill, with its double and triple effects, with its vacuum pan with its centrifugal separator, to understand the improvements made in the last twenty years. It is time for the old mill to depart; its days of usefulness are over, and yet it is with a pang of regret that we see the old give place to the new. There was an air of poetry and good fellowship about the old plantation and sugar-mill which we can never associate with the big, bustling "refinery." Somehow people seemed to be much more at home, much more welcome in the old mill than in its improved successor. There the young would gather of an evening during the grinding season for merrymaking; there both young and old with can or bucket would come for "cuite," that sweetest and purest of candies; there, too, a cup was always ready in which the visitor could taste the boiling juice. All this has gone with the old mill, and who is not sorry for it?

The coal of the Philippines appears to be rather carbonized lignite than coal. The coal exists in Luzon, and mining concessions have been granted.

ENGINEERING NOTES.

The trials of the submarine boat "Gustave-Zédé" are reported to have been quite successful, as she disappeared and attacked the ship without the latter being able to discover her whereabouts. It is not impossible that submarine boats may be useful, but they have been rather long in displaying their powers—about a century, say. It is reported that the submarine boat has successfully navigated the distance between Toulon and Marseilles.

Readers of SCIENTIFIC AMERICAN SUPPLEMENT are familiar with the plan of coating railway roadbeds with oil to prevent the raising of dust by trains. It may be interesting to learn that experiments in applying oil to country roads have been made with the same object in view. According to a report presented before the Good Roads Association, at a convention in St. Louis, on December 3, by Major M. Meigs, of the United States Engineering Corps, a trial has been given crude oil on country roads at Keokuk, Iowa, with good success. The plan followed is to sprinkle the roads when dry with oil, which forms a crust, preventing the formation of dust and keeping out the water. The experiment began some months ago, but is now interrupted by the cold weather. The kind of oil used is known as "spent oil" or "fuel oil," which can be delivered at Keokuk for $1.10 per barrel, in tank loads. A barrel of oil will cover a stretch of road 100 feet long and 12 feet wide, with a penetration ⅛ inch. To get the best results from the use of the oil the roadbed is crowned in the center. Major Meigs suggests that for sandy soil a mixture of gas tar and crude oil will possibly form a better material. The estimated cost for treating one mile of road 12 feet wide and ⅛ inch deep, including labor and preparation of the roadbed, is $141.50.

The fighting force of the United States navy, at its maximum on August 15, 1898, according to the report of the Secretary of the Navy, was made up as follows: First class battleships, 4; second class, 1; armored cruisers, 2; coast defense monitors, 6; armored ram, 1; protected cruisers, 12; unprotected cruisers, 3; gunboats, 18; dynamite cruiser, 1; torpedo boats, 11; vessels of old navy, including monitors, 14. Auxiliary navy: Cruisers, 11; converted yachts, 28; revenue cutters, 15; lighthouse tenders, 4; converted tugs, 27; converted colliers, 19; miscellaneous, 19. This is a total of 73 in the regular navy, and 123 in the auxiliary fleet, or 196 vessels in all. This fleet was manned by 24,123 enlisted men. There were 856 volunteer officers of all grades in service during the war; 456 of these ranking with the line, and 205 were engineer officers. There are now under construction: 8 first class battleships; 4 coast defense monitors; 1 training vessel; 1 sheathed cruiser; 16 destroyers; 22 torpedo boats; 3 steel tugs; 1 submarine boat; or 55 warships in all.

The Automobile Club de France announces a competition for motor car accumulators, to take place in Paris in April next. Tests will be made on the life of the cells, and on their useful efficiency, and account will be taken of the "frequency, importance, and facility of operations for maintenance," and of the weight of the cells per capacity and per output. Each battery submitted must be capable of furnishing 120 ampere hours when discharged at 24 amperes, without its terminal pressure dropping below 8·5 volts, and must not weigh more than 110 kilogrammes. Discharge tests will be made for five hours every day, the current being varied according to a specified curve between 20 and 100 amperes every twenty minutes; the 100 ampere discharge will only last half a minute in each cycle, this being followed by ten minutes' repose. While these discharges are taking place, the cells will be jolted about in imitation of the treatment they are liable to on ordinary roads. The daily charge will be given for a maximum of eight hours, but any competitor may stop the charge to his battery when he likes. The charging current will start at 30 amperes and gradually diminish to 15 amperes. Between the charge and discharge—an interval never exceeding two hours—owners of the batteries may clean them and renew the strength of the electrolyte, but no plates may be changed. Once a week a test discharge, without jolting, of a steady 24 amperes for five hours will be made. During this time, if the voltage of any battery drops below 8·5, it will be removed from the circuit, and after four cases of such misbehavior it will be considered as worn out, so far as the tests are concerned, and the tests mentioned will be systematically continued until all the batteries are worn out, but not longer than six months.

"**The United** States composite gunboat 'Princeton' is the fourth to bear the name in the United States navy," says The Army and Navy Journal. "She is of 1,000 tons displacement, is of composite construction, with her wetted surface coppered, is furnished with engines of 800 indicated horse power, has a single screw and carries a battery of six guns. The first craft to bear the name was built in Philadelphia in 1843, after the hull designs of Captain R. F. Stockton, U. S. N. The machinery and boilers were designed by the late John Ericsson, and built by the well known firm of Merrick & Towne, of Philadelphia. The hull was built by John Lenthall, who afterward became chief of the Bureau of Construction and Repair. This 'Princeton' was the first ship fitted with a screw propeller in the navy, and her cost, complete in all respects, was $212,615. The second of the name was fitted with engines and boilers designed and built by the venerable Charles H. Haswell, and is recorded as having 'performed remarkably well under steam and canvas.' No. 3 was built at Boston, launched in 1851, cost a total of $359,460, and her engines were designed by John Eriesson, her boilers by Benjamin F. Isherwood, late chief of the Bureau of Steam Engineering, her hull by Samuel H. Pook, U. S. N. The machinery was built by Murray & Hazelhurst, of Baltimore, Md. This craft was far from being the success anticipated, and having failed to come up to expectation as a cruiser, was first laid up in ordinary at the Norfolk navy yard, and afterward, having been divested of her boilers and machinery, was commissioned at Philadelphia as a permanent store and receiving ship. Remaining here until 1866, the 'Princeton' was surveyed, condemned and sold, and so the name disappeared from the navy list until 1896, when the present vessel takes up the name and renews the fame of the historic forerunner of the modern screw navy."

MISCELLANEOUS NOTES.

An eruption is reported in the crater of Vesuvius, which was formed in 1875, and two currents of lava, each 20 meters broad, reached the slopes of Monte Somma. It is thought from the scoriaceous nature of the current that the eruption will be harmless.

The hull of the torpedo boat destroyer "Bailey," built by Charles L. Seabury & Company, of Morris Heights, Harlem River, has been completed and the vessel will be launched as soon as the river is free of ice. The engines are well under way and will be placed in the boat after it is launched. It is expected that all will be ready for the official trial trip by April 1.

A mountain observatory has been erected on Mont Mounier, in the Maritime Alps, about 56 miles northwest of Nice. The station is about 2,816 meters above sea-level, and as it will be connected by telegraph and telephone with others, some useful results will no doubt be obtained. The establishing of this observatory is the work of M. Bischoffsheim, who founded that at Nice.

Quite a novelty as an adjunct to swimming costume is the webbed glove introduced by Hugo Steinbacher, of Munich. The idea is to transform the hands of the swimmer into something like the webbed feet of the duck and other swimming birds, with the view of promoting speed of motion through the water. Whether this webbed glove will be of any advantage in that respect remains to be proved.

An industrial exhibition is to be held at Düsseldorf, in 1902, similar to that visited with so much interest by the Iron and Steel Institute, in 1890. The Northwest Group of Iron and Steel Makers, the Association of German Metallurgists, and the Düsseldorf Association for Trade Interests have combined to give importance to the exhibition, for which the municipality will furnish the land and also contribute a guarantee fund.

The Waring fund has now reached $100,000, and this eminently common sense method of showing appreciation to the great sanitary engineer will result in Mr. Waring's widow and daughter being comfortably provided for. Nearly 1,700 people subscribed to the fund. After the death of both Mrs. Waring and her daughter the money is to revert to Columbia University for the endowment of a chair of instruction in municipal affairs.

Something novel in the way of decorating station grounds has been accomplished by the Michigan Central Company at Ypsilanti. Flower beds and plants have been arranged to display a correct representation of the battleship "Maine," built in proportionate dimensions, one-sixth the actual size. It is 53 feet in length, 10 feet wide, and 5 feet from the water mark to the lower deck, the top of the masts being 24 feet from the ground. There are 4 formidable looking guns and the usual flags and pennants flying from the mastheads. More than 117,000 plants were used in its construction.

The Eiffel Tower, Paris, is put to a novel use. The Parisian nose is sensitive to everything, but the omnipresent garlic and the inhabitants of that city do not propose to breathe carbon or sulphur fumes or have their buildings covered with soot. The government is in earnest to suppress the smoke nuisance and is doing most valuable work in this connection. High up in the Eiffel tower an outlook is kept for violators of the ordinance relating to the smoke nuisance, and an offending chimney can be spotted many miles away, and there is little difficulty in locating it, and the nuisance is promptly abated.

A first class thoroughfare in Charlottenburg, one of the suburbs of Berlin, Germany, will be found in the Bismarck Strasse, if the proposed improvements are carried out. The street would then be 200 feet wide, distributed as follows: In the center, a driveway for through traffic 52 feet wide; on each side of it, a footpath 11 feet wide, planted with trees; then, on one side, an equestrian path 13 feet wide and on the other side a cycle path of the same width; then again, on each side, a strip of 5 feet with a row of trees; then, near each curb, a driveway of 16½ feet for local traffic, and lastly sidewalks each 28½ feet wide.—Oesterreichische Monatschrift für den öffentlichen Baudienst.

A German service contemporary gives some interesting details on the marching performances of the troops engaged in various celebrated campaigns. Thus the highest average of distances marched by troops during the campaign of 1796 is to be credited to the French, who, on the authority of Gen. Lewal, marched daily on the average a distance slightly exceeding 25 kilometers. In the war of 1866 the highest average was that attained by the Prussians, marching 22 kilometers, while during the Franco-German war the highest averages were for the Germans (during the march on Sedan) 21 kilometers, and for the French troops 15. In the case of the mounted arm, the record is held by Murat's cavalry, which marched 800 kilometers in twenty-four days during the operations of 1806, a daily average of over 33 kilometers.

Massachusetts has been the first to establish a State sanitarium for consumptives, founded upon the principles of the great sanitaria in Europe, and a special interest attaches to the first report of the institution, particularly as the legislatures of some other States are to be asked to create like institutions. The visiting physicians of the hospital say that it has been a source of gratification and surprise to see how quickly and contentedly the patients have adopted the special hygienic methods used for treatment, viz., almost constant life in the open air, whether by walking or reclining on the piazzas, and the ingestion of nourishing food. The remarkable change in the aspect of these patients after even a short stay at the hospital at Rutland would convince the most casual observer of the efficacy of the treatment upon the general condition of the patient. They say the moral effect of the somewhat military discipline is an important factor in accomplishing at the hospital what would be almost impossible at home. They believe it will be not only a benefit to individuals, but an object lesson to the whole community, to prove the value of fresh air and good food for not only the cure, but the prevention of disease.

SELECTED FORMULÆ.

Laxative Lozenges.—Take 1 ounce each of powdered senna, jalap, and sugar, and make into a paste with 5 ounces of tamarind pulp, cut into lozenges weighing 45 grains each, and coat with melted chocolate.—National Druggist.

To Remove Warts.—A French medical journal says that Kaposi prescribes the following:

Sulphur	150 grains.
Glycerin	375 "
Pure acetic acid	75 "

Mix, and apply to the warts every day, when the latter will shrink up and drop off in course of time. The mixture should be shaken before use.—National Druggist.

Koumys Substitute.—To prepare a substitute for koumys from cows' milk, the Ap. Ztg. gives the following directions: Dissolve 15 grammes (¼ ounce) of grape sugar in 120 cubic centimeters (3 fluid ounces) of water. Mix 1·2 gramme (18 grains) of well washed and pressed beer yeast with 60 cubic centimeters (2 fluid ounces) of cows' milk. Mix the two liquids in a champagne bottle, fill with milk, stopper securely, and keep for three to four days at a temperature not exceeding 10° C. (50° F.), shaking frequently. The preparation does not keep longer than four to five days.

Aromatic Cachous.—

Oil of peppermint	4	drachms.
Oil of cloves	75	minims.
Mastic	6	drachms.
Cascarilla	6	"
Orris root	6	"
Gum arabic	1½	ounces.
Catechu	2½	"
Licorice extract	20	"
Water, a sufficient quantity.		

Boil the solid drugs, which should be in powdered form, until a pasty mass is obtained, then add the liquids, and, when cooled to a proper consistency, cut or roll into the desired size and shape.—National Druggist.

Paper Barometers.—

1. Copper chloride	1	part.
Nickel oxide	3	"
Cobalt chloride	4	"
Gelatin	80	"
Distilled water	800	"
2. Cobalt chloride	1	"
Gelatin	10	"
Distilled water	100	"
3. Copper chloride	1	"
Gelatin	10	"
Water	100	"

Paper saturated with 1 becomes green in dry weather; with 2, blue; with 3, yellow. In wet weather the papers are colorless.—National Druggist.

Nicotine in Tobacco Smoke.—To demonstrate the presence of nicotine in tobacco smoke, Kissling uses a bottle half full of water rendered faintly acid with sulphuric acid; two tubes pass through the stopper, one dipping into the fluid, and having a cigar inserted in the upper end; through the other, much shorter tube, the assistant draws the smoke in the ordinary way of smoking. When a portion of the cigar is consumed, a few drops of Mayer's reagent are added to the liquid, in which a copious precipitate is produced in the presence of nicotine. Further evidence of nicotine may be obtained by rendering the solution alkaline with soda and distilling. The idea that a picoline base, and not nicotine, causes the reactions described is not borne out by this experiment. Previous investigations by the author also show that tobacco smoke contains a relatively large proportion of nicotine, and never more than a very small proportion of picoline base.—Chem. Ztg., lxxviii., 805.

Cleaning Lenses.—Miethe gives warning as to the care necessary for the protection of lenses against injury in cleaning. Glass is a comparatively soft substance, and the fine dust deposited from the atmosphere consists mostly of minute grains of sand, at least one and a half times as hard as glass. Optical glass is softer than ordinary window glass, and to the all-pervading deposit of dust are due most of the scratches and consequent deterioration of lenses. Any material used in the process of cleaning must, therefore, be free from dust, and possess other requisite qualities. First among these is a capacity for removing grease. Leather is frequently recommended for cleaning glass, especially wash leather; but it is very unsuitable, as it does not remove grease, and may sometimes deposit it. Well washed cotton cloths he thinks far more suitable. Linen especially has the property of removing dirt and grease from glass, but it is difficult to clean close up to the mount with a cloth, and for this purpose pith is most suitable. The best varieties of pith are obtained from rushes, the sunflower, or the elder tree. For cleaning large lenses circular pieces of pith are glued side by side on a piece of cork, and this species of brush is passed over the surface of the lens without too much pressure. The author warns against the use of any polishing powder; if dirt cannot be removed by rubbing, liquids must not be used which are liable to attack the glass. Even water has some effect, as is well known, and should be used sparingly. Among liquids admissible for the removal of grease are mentioned alcohol, ether, and oil of turpentine. The latter we must say we regard as distinctly objectionable from its well known disintegrating action on glass. Manifestly, from the risks well known to opticians which are here pointed out, we would say that a prime element in the care of lenses is to guard them as fully as practicable from becoming dirty. This is more especially important in the case of microscopic objectives. The lenses should never be touched with the fingers, the objective should be put away in its case when not in use, and stray particles of dust which may fall on the back lens removed by lightly brushing with a camel's hair brush, which brush should be kept in a close box so as to accumulate no supply of dust itself. Japanese paper is probably the best material with which to remove fluids from immersion lenses.—Photo. Times.

THE PARIS CYCLE AND AUTOMOBILE EXHIBITION.

AMONG the interesting exhibits of the recent Salon du Cycle et de l'Automobile at Paris, there was a tricycle phaeton in which the motor acted solely upon the front wheel, which was both a driving and steering one. The originality of this vehicle, which was exhibited by the Hurtu establishment, resides in the method of actuating this wheel, the axle of which always remains parallel with that of the hind wheels (which are simply carriers), while the wheel turns around its axis of revolution in order to permit of steering the carriage. Such a result is obtained very simply by a ball and socket joint, which, mounted upon the axle, serves as a pivot to the hub of the wheel, which is itself controlled by a fork and a steering lever. A groove formed in the hub, and into which fits a key mounted upon the wheel, assures a carrying along of the latter by the axle despite the obliquity of the mounting. Such a system could not be recommended for heavy carriages or for those running at a high speed, but it appears to be adopted for light vehicles, and seems to furnish an elegant and simple solution of the question of the single-wheeled motive fore carriage. The transmission of the motion of the motor to the axle of the driving wheel is effected through the intermedium of a belt and stretcher controlled by the pedal. On a normal run the belt is always taut, and the pedal is raised by means of a spring of which the tension assures sufficient adhesion. Upon bearing upon the pedal, one loosens the belt, which can then slide and permit of all degrees of speed reduction. Upon further pressure, the belt is thoroughly loosened for a stoppage, and upon still further pressure, the pedal sets in action brakes that act upon the hind wheels. There are thus but two parts to be maneuvered—one by hand for steering and the other by foot for changing speed, stoppage, and acting upon the brake. By adding to the vehicle a mechanical change of speed, it would be possible to ascend any gradient with two persons as a load.

In the domain of automobile carriages—and by this we understand vehicles of which the weight exceeds half a ton—we have few novelties to call attention to, except, perhaps, certain interesting tentatives with a view to their simplification or convenience of maneuvering. Thus, for example, the Peugeot carriages, the lighting of which has been done up to the present exclusively by incandescence, are beginning to receive the electric light, the numerous advantages of which are becoming more and more appreciated, while at the same time its inconveniences are disappearing through improvements and a better understanding of it among those who use it.

Certain manufacturers are trying likewise to suppress the cooling of the cylinder by a circulation of water, with a view to simplifying the carriage and lightening it. Some facilitate the cooling by an energetic ventilation obtained by means of a small fan which is actuated by the motor so much the more quickly in proportion as the latter revolves with greater speed. Others are content to increase the radiating cooling surfaces and place the motor in the current of air caused by the motion of the vehicle. Should such tentatives be crowned with success (and it is to be hoped that they may be), the gasoline automobile carriage will by this fact have made an important progress.

Another progress no less important in the way of realization is the suppression (or at least the reduction) of the vibrations produced by the motor while running, and especially during the stoppage of the carriage. In certain new systems this is brought about by the use of balanced motors, as in the vehicle exhibited by the Société des Moteurs Gobron et Brillié. The motor of this carriage consists of two vertical four-period cylinders, the cycles of which lap so as to give one motive impulsion to each revolution of the axle. The explosion of the detonating mixture is produced for each cylinder between two pistons which move in opposite directions and thus balance their vibrating actions. In these motors the carbureter is suppressed and replaced by a mechanical distributer which measures and furnishes the quantity of gasoline necessary for each explosion. The capacity of the cavities of the distributer renders impossible the use of an excess of fluid, and consequently an exaggerated carburation accompanied with an excessive output, an incomplete combustion, and a disagreeable odor. The motor, always in operation upon the arrested carriage, runs without noise, odor, or perceptible vibration.

Aside from these particular arrangements, we saw nothing that merited special description. The majority of the manufacturers whose reputation is now established in the automobile world exhibited beautiful and comfortable vehicles of which a eulogium is no longer to be made, but the improvements in which relate especially to details of construction and secondary modifications that it is out of the scope of our article to describe.

Up to the present we have mentioned gasoline carriages only, and, until a new order of things, gasoline will reign upon the road, with the explosion motor as executive power, for the Salon included but one steam carriage, and the merits of this we were unable to estimate for want of sufficient data.

But, although gasoline is queen of the road, and also undisputed queen upon the highway, it ought to prepare to divide its sway with a young rival in the streets of cities, and this rival, which is electricity, seems as if it must victoriously sustain its claims, although its representatives are not yet very numerous in the Salons du Cycle et de l'Automobile. Up to the present, the principal idea of manufacturers of electric carriages has been to create the electric hack, of which large outputs are certain, but of which the economic difficulties are great, seeing the limits imposed upon the receipts by the very nature of the application. Now, the fact is not to be disguised that, although the electric hack has an assured future, its present is still quite precarious. The competition of 1898 demonstrated that an exploitation of electric hacks can make both ends meet or realize honest profits only on condition of being got up upon a large scale. The hired horse, the pleasure carriage, or the business phaeton do not have to undergo so severe economic exigencies, and, in our opinion, are capable of more easily lending themselves to a more immediately remunerative utilization. This was understood by the majority of the manufacturers whose vehicles figured at the last Salon. We may mention particularly the small phaeton with motive fore-carriage (Fig. 2) exhibited by M. Mildé and constructed with a view to responding to the desiderata of such amateurs as wish a light (650 pound) carriage at a low price ($600), and one that can be run cheaply, say, as in this case, at an expense of sixty cents a day inclusive of the recharging of the battery. This vehicle may be considered as a low-wheeled phaeton in which the horse is replaced by a motive fore-carriage. This latter consists of a single wheel

FIG. 1.—THE HURTU GASOLINE PHAETON.

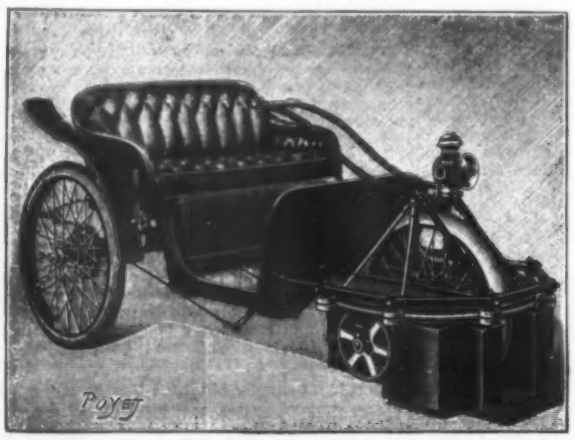


FIG. 2.—THE MILDÉ ELECTRIC PHAETON.

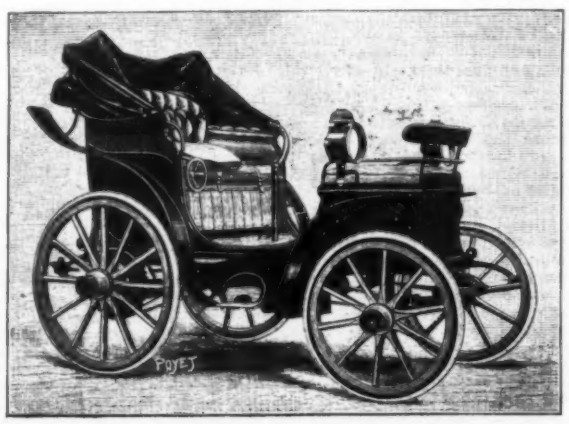


FIG. 3.—MESSRS. BOUQUET, GARCIN & SCHIVRE'S ELECTRIC PLEASURE CARRIAGE.

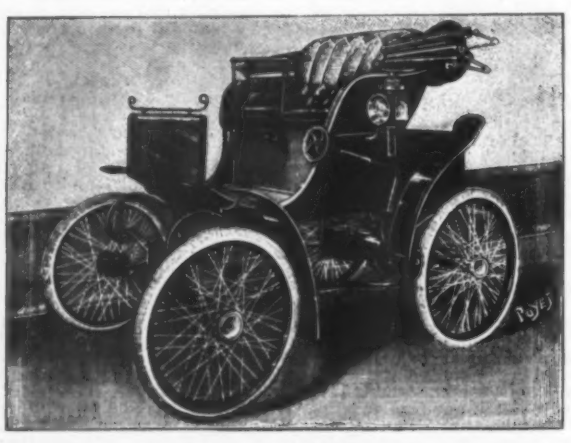


FIG. 4.—THE RIKER ELECTRIC PHAETON.

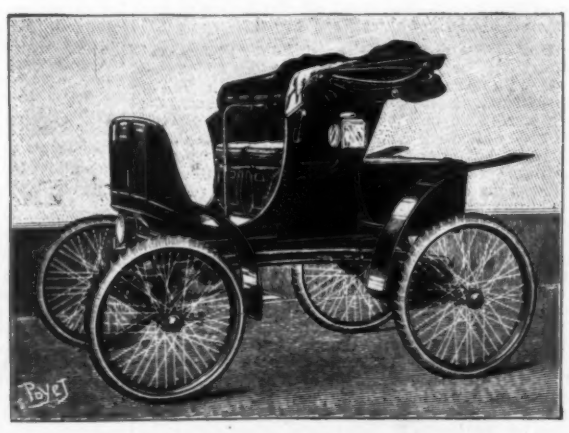


FIG. 5.—THE COLUMBIA ELECTRIC PHAETON.

ENGINEERING SOCIETY LIBRARY 9335 UNIVERSITY OF MICHIGAN

that supports a disk from which are suspended the motor and three batteries of accumulators of five elements each. The disk revolves between eight rollers mounted upon the front of the vehicle and receives its direction through a double bar fixed upon it by means of four uprights. The battery, of 15 Fulmen accumulators of the type B_{11}, is of 15 amperes-hour and furnishes an effective electromotive force of 28 volts, say 3·48 kilowatts-hour. It actuates a motor series of from 500 to 600 watts that actuates the front wheel through a gearing and makes 2,000 revolutions a minute for the normal speed of 9 miles an hour.

The combinator, which is arranged under the seat, is controlled by a lever placed at the side within reach of the driver's right hand. It acts in leaving the batteries always coupled in tension. The start is made in two additional resistances interposed in circuit with the motor; the second speed is made by shunting one of the rheostats; and the third (the normal speed) in shunting the second resistance. A fourth speed (11½ miles an hour) is obtained by placing a resistance in derivation upon the inductors, thus diminishing the excitation and increasing the velocity of the motor, but at the expense of the rendering.

A maneuvering of the back of the combinator produces successively a running backward and a running forward. A pedal serves to break the current for a slowing up, while a second pedal breaks the current and actuates a mechanical band brake that acts upon pulleys mounted upon the hind wheels. According to M. Greffe, the inventor and manufacturer, the phaeton is capable of running from 36 to 42 miles upon a level without recharging. As its weight under a load is 960 pounds (of which 300 are for the two passengers), the carriage to be effected would be about 50 tons-mile, and the corresponding electric expenditure about 250 watts-hour per ton-mile. These figures agree very well with those furnished by the competition of hacks.

It is in an entirely different order of ideas that have been studied the pleasure carriages exhibited by the Société des Voitures Electriques et Accumulateurs, system B. G. S. (Bouquet, Garcin & Schivre), a specimen of which is shown in Fig. 3 by way of example. These light vehicles are designed for long trips, say of 60 miles, upon medium roads. The accumulators used therein are of a special type concerning which the inventors are at present reticent, but the mystery about which will, if we are properly informed, cease at the competition of accumulators in April next. The peculiarity of the electric system of the B. G. S. carriages resides in the motor with two induced windings, with unequal bobbins, of which the number of spirals to each of them is such that the electromotive forces developed at every instant shall be respectively proportional to the numbers 5 and 3. The combinator permits of successively coupling the two induced bobbins in tension, separately or in opposition, for gradually increasing speeds, represented respectively by 5+3, 5, 3, and 5−3=2. Upon starting, the combinator introduces into the circuit resistances that are afterward suppressed. The combination of the two windings permits of leaving all the accumulators in tension and of thus discharging them equally.

If the carriage, which has a pleasing aspect, responds to the hope of its inventors, it will doubtless open up an era of electric touring, since, with the development of works for distributing electric energy, and with the long trips that the vehicle will permit of making, one will soon be able to undertake a tour of France without any fear of having to lie to for want of a current.

The electric hack was represented by the Compagnie Générale des Voitures Electromobiles, whose vehicles will form the subject of a special article at some time in the future.

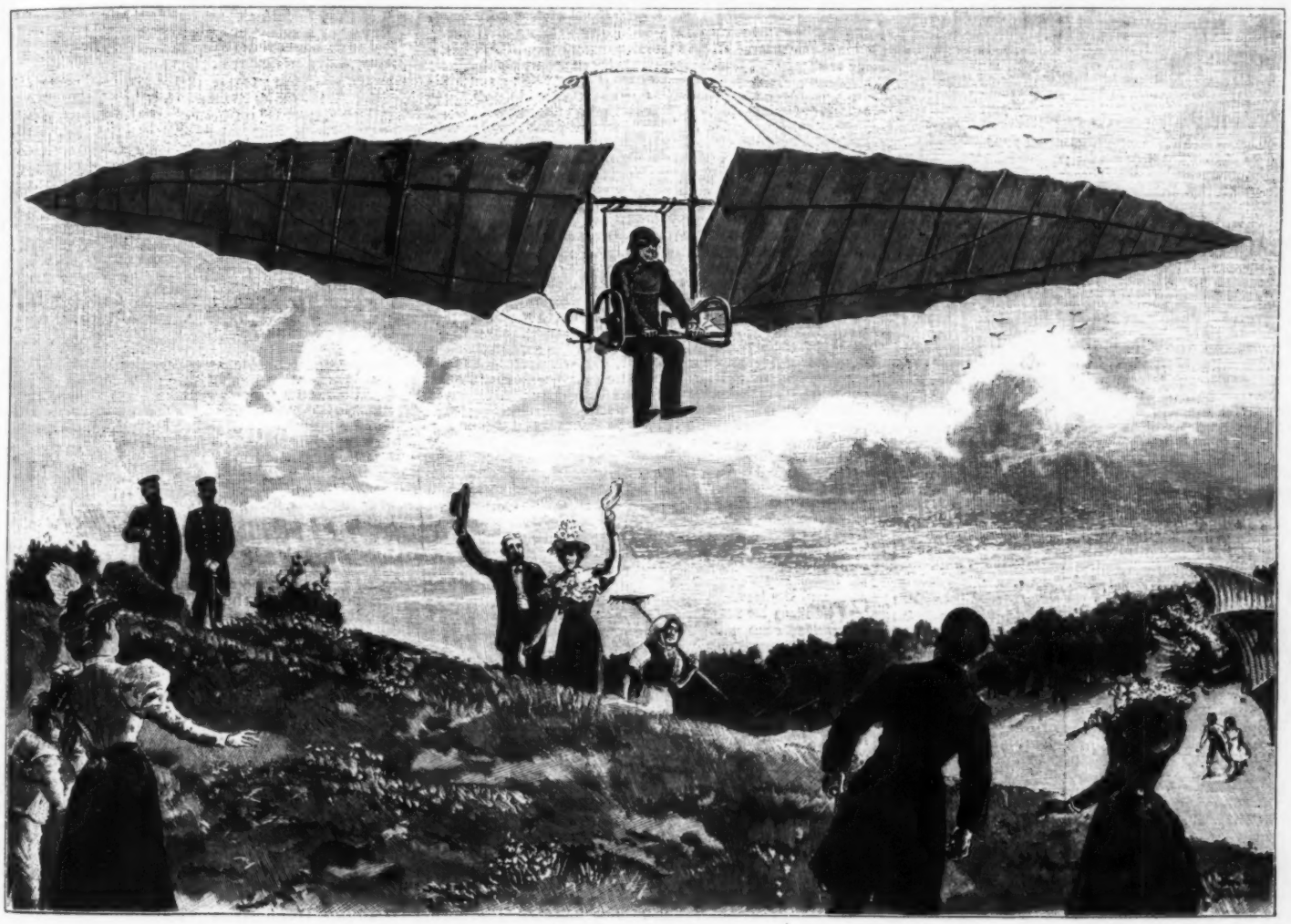
Finally, it only remains to mention two pleasure carriages of American origin, one of which, the Riker phaeton (Fig. 4), was exhibited by the Compagnie l'Automobile, and the other of which, the Columbia phaeton (Fig. 5), although not represented at the Salon, is frequently to be seen upon the streets of Paris. We have as yet too few precise data as to the performances of these vehicles to permit us to pass judgment upon them, and especially to institute a comparison between them (that will be the work of future competitions), but we find in them the proofs of a laudable emulation between French and American manufacturers of which the Exposition of 1900 will certainly mark the apogee.

For the above particulars and the illustrations we are indebted to La Nature.

A NEW FLYING-MACHINE.

IN spite of all failures, in spite of numerous mishaps, many minds are still endeavoring, theoretically or practically, to solve the problem of artificial flight. The dirigible balloon and the flying-machine are contrivances which, to a certain extent, supplement each other. Both methods of flying are still in a state of development; but the time has passed when all attempts at flying are sneered at and derided. In the last few decades the art of flying has developed so prodigiously and has made such astonishing progress, that at no distant day the practical solution of this problem may be expected. The German government has taken such interest in this matter of aerial navigation that it has appropriated $200,000 for experiments with the dirigible air-ship of Count von Zeppelin.

Following in the footsteps of former investigators, many inventors are now engaged in constructing flying-apparatus without the use of balloons. The aeronaut, in order to fly with such an apparatus, runs down an inclined plane, and the air, as it gathers beneath the wings, lifts him and carries him on. Buttenstedt's apparatus, which is at present being used in Zehlendorf, near Berlin, is operated in a like manner. The wings of this contrivance during flight remain perfectly flat, and do not become concave. Buttenstedt claims that the pressure on the front portions of concave wings, when the aeronaut is moving at a high rate of speed, is so great that the apparatus will be upset. It will be remembered that Lilienthal, not long ago, was killed by the overturning of his apparatus in mid-air.—Illustrirte Zeitung.



BUTTENSTEDT'S FLYING-MACHINE IN MID-AIR.

A London optician now lends microscope objects under somewhat the same conditions as persons obtain books from a lending library.

SLEEP, AND WHAT IT DOES FOR US.

A BRIEF but striking statement of the functions and curative value of sleep is given by Dr. Ewart in his recent Harveian lecture. We give below several of the most interesting paragraphs. Of the absolute necessity for sleep as distinguished from mere rest, Dr. Ewart says:

"No amount of simple rest of the body can do duty for sleep. Though mere repose may partly satisfy the needs of our vegetative life, sleep alone, that profound sleep which the poet has likened to death, can make good the wear and tear of the higher nervous centers. . . . . It is the privilege of some to command sleep at any moment, but it is probably exceptional to combine this facility with that of remaining awake at will—a dangerous power when it is abused. Some possess the opposite peculiarity and are subject to the invincible desire for sleep after a definite expenditure of nerve energy. By this they are protected against exhaustion. Interesting physiological speculations, and some practical notions also, are suggested by the remarkable relief and freshness which they derive from even a very short period of sleep. Much tissue repair cannot have taken place during those few minutes of profound sleep which will restore a jaded man to full activity. The energy which he subsequently develops must have been there when he fell asleep, yet it was unavailable. It is therefore clear that these brief and irresistible slumbers are essentially different from the long sleep of the night, and that we might turn both the short and the long sleep to separate therapeutic account. . . .

"The various degrees of sleep range from coma, where both the nerve cells and the conducting fibers are absolutely impervious, to the light sleep of those whose irritable and quick nerve protoplasm is immediately thrown by the touch of a feather or by the slightest sound into that state which means open conduction and full consciousness. The disordered cerebration of delirium and of dreams almost suggests a possibility that orderly communications may pass between local groups of cells, and this might perhaps explain the good counsel which is bred of the night. But these incubations would be merely local settlings of the balance of the day between cells disciplined to collaboration, and would be during sound sleep incapable of a wide diffusion throughout the mental sphere.

"Sleep then would seem to have two offices, both fulfilled in the long sleep of the night which it is our usual endeavor to secure for our patients, viz., that of favoring the slow anabolic changes of repair and that of interrupting consciousness by uncoupling the chain of neurons or conceivably by relaxing protoplasmic tension or tone. This relief of tension is, it would seem, the only office performed by the shorter spells of sleep, and therefore the two forms of sleep suggest two therapeutic objects. . . .

"The systematic prolongation of sleep for the cure of disease is one of our opportunities hitherto little used. . . .

"In various nervous affections, including the mental, its renewed trial, combined with suitable methods of feeding, might lead to encouraging results. Better suited

perhaps to our everyday needs is a systematic resort to the shorter sleep. Like the light installments of food which restore the lost function of appetite and digestion, short sleep in the day may be essential to the cure of nocturnal insomnia. Our growing wealth in hypnotics warrants a hope that a suitable agent may yet be found which in that direction would minister to the health of the invalid and might command the luxury of sleep at any opportune time for the convenience of the worker.

"Body rest as a systematic therapeutic agent has long found its place in our modern treatment for patients whom weakness alone, in the absence of medical advice, would not have compelled to take to their beds. . . . . Its methodical employment forms an essential part of the Weir-Mitchell plan, but its most striking instance is that of the open air rest cure for phthisis, which within quite recent years has largely replaced at foreign sanatoria the previous method by muscular exercise. The pendulum of medical opinion has swung toward the principle of physiological rest."

THE ETHICS OF THE BABYLONIANS AND ASSYRIANS.*

IN contrast to the Egyptians, of whom you have just heard, the Babylonians did not occupy their minds to any great extent with the thought of the future life; in fact, if they had thought very much of the life after death, it could have had only a lowering effect upon their ethics; for they pictured existence in the future world as exceedingly gloomy. There was no happines in store for those who had died. A great, dark cave, filled with gloom and damp, would receive all people, without any exception. The dead retained consciousness, but were unable to move about, without the ordinary wants of life, yet able to suffer pangs of hunger. There appears at later times to have arisen a certain reaction against this view, a feeling that at least some persons, more favored by the gods, might escape this fate; but, in general, the fate of all mankind was the same; and we have only the beginning of the attempt to picture the future in more cheerful colors.

Before leaving this subject, I will read a few lines from one of the most famous literary productions of Babylon, which will illustrate the general view of the life after death. It is the description of a journey of the goddess Ishtar to the nether world. The legend in which the description occurs symbolizes the change of seasons. Ishtar is the goddess of fertility, who, in the winter time, is supposed to be sojourning in the lower world. "To the land of darkness Ishtar, the daughter of Sin" (that is, the daughter of the moon god) "directed her steps, to the house of darkness, to the house whence no one issues, along the road from which there is no return when once it has been trodden, to the house whose inhabitants are deprived of light, the place where there is no nourishment, no food; they have no light; they are in dense darkness; and they are clothed like birds in a garment of feathers." If a view of that kind had any influence at all upon them, it must have been rather to discourage an ethical life; for it would have made them feel that, no matter what we do here below, we are all coming to this enormous dark cavern. It is remarkable that this gloomy view of the after-life does not seem to have had any direct influence over the Babylonians, though in this they by no means stand alone.

For example, the Hebrews do not seem to have occupied themselves very much with the thought about the future world. It is supposed by some scholars that there is no reference even to a future life in the Old Testament. That is not so: they did believe in a future life; but they did not occupy themselves very much with it; and we have traces of an early period among the Hebrews where the ideas did not differ very largely from the one we find in Babylonia. If you take up the famous chapter of Job describing the life after death, you will find a striking resemblance to the description which I have read here. The Hebrews developed other ideas and other doctrines in later times; but at no time do we find them occupied very much with the thought of the future. It was with the present that they were concerned; and that is a characteristic feature, too, of the Babylonians. It was the present life which occupied their minds.

What, then, was the source which led them to produce ethical ideals? for there must have been some motive—some source—some purpose, it may be of a high or low character, but some purpose that drew the people toward the development of ethics. It was the view they took of the gods. A great many of the powerful deities in whom they believed were not favorably disposed toward man; but it is to the early period that this statement applies, rather than to later times. The gods do not like the advance of men, they look with a certain suspicion upon an increase of knowledge and wisdom and the developing power of man; but even at an earlier period (say 2500 B. C.) we already find a differentiation between two classes of deities: superior gods, or gods who, on the whole, are favorably inclined toward men; and a second class—the demons—the spirits who, on the whole, are unfavorably inclined toward men and are gods of mischief, thwarting people in their aims. In that way the Babylonians solve the problem of good and evil. The gods themselves have a certain control over these demons and spirits; but they can only control them when they are appealed to; and, moreover, the demons and spirits outnumber by far the gods. The gods are in a great minority. There is a sufficiently large number of them (as scholars know to their pain, when they wish to find out how many gods the Babylonians had), but they are very small as compared to the number of demons and spirits, of whom there are thousands and thousands.

Disease was due to a demon that entered the body. A misfortune in business affairs, in setting out on a journey or an accident on the boat; or fixing upon an unlucky day as a wedding day; accidents that happened on the road; as you walked along the street a slip or a fall; all these little things were attributed to the demons. The gods were concerned with the larger affairs of life and generally favorable to man. For instance, one of the most important deities—one that has the very greatest power in literature—is the god Ea. He was the protector of humanity. There was only one way of overcoming the ills and misfortunes of life, and that was to try and get rid of the influence of these evil demons and spirits; and to do that you needed the mediation of a priest, who, upon appeal to the gods, could exorcise the spirits. The idea is a perfectly familiar one to most of you, because the Babylonians do not differ from other nations of antiquity and modern times who still believe in the existence of demons and spirits and the exorcising of them.

The Babylonian gods were not the kind of beings with whom you could get into close association. The idea of mediation—of mediatorship through the priest—is very prominent among the Babylonians; and this idea goes so far that, in the course of time, you do not even approach the greatest god—say the god Ea—directly through the priest; but you have to approach him through another god, Marduk, who is known as the son of this Ea. This son is asked to go and intercede with his father.

This view taken of the gods is the first and the primary factor in an inquiry as to the ethics of the Babylonians. The second point (which, however, stands in close relationship with the one just mentioned) is the view that they took of sin. It is to this view that I wish, more particularly, to call attention. The idea of *sin* among the Babylonians, as among other Semites, seems to have been not any intentional wrong doing, but an inability, on the part of an individual, to just strike the right thing. The very word for sin, in several of the Semitic languages, means "To miss the mark." Sin is, therefore, an unintentional act. The Babylonians cannot conceive of a man deliberately setting out to do wrong; he likes to do what is right, but is prevented from carrying out his good ideas, and thus he misses the mark. He tries to hit it, but he fails. That is the idea of sin among the Babylonians; and despite the high ethical character which is shown in some of their religious productions, they never passed beyond this notion, that sin is simply due to the weakness of man, the inability of man to carry out what he really wants to do. This notion of sin colors the entire religion, and, as I say, it stands in close relation to their view of the gods: because there you see it is based on the same feeling, that the gods, in some way or another, don't care so much for man. They are not near him; and here, on the other hand, is this great body of demons and evil spirits, constantly on the lookout for doing mischief.

In consequence of this view that they take of sin, the best expression of the ethical ideal among the Babylonians is found in their religious literature, and particularly in that phase of the literature which is the direct offshoot of pure incantations. The priests, when they wished to exorcise a spirit, had always recourse to certain symbolical acts; and then they combined with these symbolical acts certain appeals to the gods. These appeals, in the earlier stage of religion, were powerful, not so much for what they contained, but because of a certain supposedly sacred power that rested in the words that were spoken: and there arose, among the priests of Babylonia, a complete ritual, to be used on various occasions, consisting of the kind of words—the words, the phrases, the sayings, the maxims—that were to be spoken by the priests or by the person who came to the priest, in conjunction with symbolical acts of one kind or another, in order to free themselves from the influence of the evil spirit. In the earlier stages, of course, these incantations rather impress one as not having very much sense. They were a mixture of words, supposed to have a sacred, mystical power; and probably, if they were perfectly clear, they would not have had that. They made a deep impression upon the minds of those who came to the sanctuary for the purpose of getting rid of the evils from which they were suffering. They were intentionally obscure; but the religious literature advanced very largely from these pure, semi-nonsensical incantations to really strong words of appeal to the gods; and we have among the Babylonians a large number of very fine prayers and hymns; but these prayers and hymns appear in almost all cases in direct connection with an incantation. Even these penitential songs—utterances of the very finest religious character—are attached, in almost all cases, to pure incantations; and all recited in connection with magical rites. I cannot stop to speak of the various symbolical acts performed by the Babylonians; but they did not differ from those the Egyptians had and often performed in the middle ages. For instance, the burning of the images of the demons or spirits was quite a popular practice. In the middle ages, you will remember, in order to free themselves from the witches, people had little images of wax prepared and set fire underneath them; and as the image melted, certain words were said, and in that way you were supposed to be rid of the witches.

The psalms to which references have been made—the penitential psalms—represent a portion of the ritual prepared for persons who came to the sanctuary with a feeling that they had sinned.

I have spoken of the idea that they had of sin. It follows from this idea that a person became conscious of having committed a wrong only when some evil came to him, or some misfortune. He knew that if a misfortune came—if something or other had happened to him—there was some reason why he had missed the mark; and thus there was developed, in the course of time, among the Babylonians, the idea that although the gods remained far off, still there was some reason why the demons did get the power over an individual. The latter had omitted to do something which this god or the other required of him, he did not know exactly what it was; but he reached the conclusion that, when a misfortune occurred, he would attribute it directly to one god or the other (he often did not know which god it was); accordingly, in these prayers, he says, "Whichever god I have offended, may he forgive me."

What kind of offenses were they? In general, those of a ceremonial character. The religion of Babylonia was full of forms and ceremonial rites of all kinds; and great stress was laid upon the proper performance of them; and if not properly performed a disaster was sure to follow. Nobody was free from the obligation to perform these rites in the proper way; least of all, the kings and priests. If the king did a wrong, it was of much greater importance than for a private individual; if the king failed to carry out a certain religious rite, in the observance of any particular festival, with all the little details connected with the observance of the same, the whole land would have to suffer; for the king was always regarded as standing much nearer to God than the rest of the people. He was responsible for the welfare of the country and, what is more, was held responsible for it; so that, if he did anything wrong, the whole country would suffer.

Therefore, the sense of guilt is generally accompanied with the feeling that the person has failed to perform some kind of rite or the other; but we pass beyond this stage among the Babylonians. They also reached the conviction that a person who may be punished by a misfortune could assign some cause for it: he has failed to do his duty in this direction or the other; and this proved, at the same time, the limit of ethical development. You will see from the specimens I will read, presently, that while they never passed beyond the feeling that you are only conscious of sin after something has happened to you, still, within this limit, they reached out to a very high plane. I shall now read a specimen that will show the Babylonians, too, had their Ten Commandments. Here in the midst of an incantation which begins in this way:

The evil *utukku, alu, ekimmu,*
The evil *gallu*, the evil god, *rabisu,*
Labartu, labasu, akhkhazu,
Lilu and *lilit* and *ardat lili,*
Sorcery, charm, bewitchment,
The sickness, the cruel artifice,
Their head against his head,
Their hand against his hand,
Their foot against his foot,
May they not place,
May they never draw nigh.
Spirit of heaven, be thou forsworn!
Spirit of earth, be thou forsworn!

Right in the midst of this incantation a priest asks the god why this person has been punished and enumerates a long series of wrongs that he may have committed and for which a misfortune has been sent. He inquires:

Has he sinned against God,
Is his guilt against a goddess,
Is it a wrongful deed against his master,
Hatred toward his elder brother,
Has he despised father or mother,
Insulted his elder sister,
Has he given too little,
Has he witheld too much,
For "no" said "yes,"
For "yes" said "no"?

. . . . . .

Has he used false weights?

. . . . . .

Has he taken an incorrect amount,
Not taken the correct sum,
Has he fixed a false boundary,
Has he removed a boundary, a limit, or a territory,
Has he possessed himself of his neighbor's house,
Has he approached his neighbor's wife,
Has he shed the blood of his neighbor,
Robbed his neighbor's dress?

. . . . . .

Was he frank in speaking,
But false in heart,
Was it "yes" with his mouth
But "no" in his heart?

Directly with these purely ethical wrongs that he may have committed are also enumerated certain ceremonial observances that he possibly may not have carried out in just the proper way. Bearing in mind the limitation of the idea of sin, it is certainly remarkable to find the Babylonians producing prayers and hymns that have properly been compared to the biblical Psalms. Some of the phrases found in these hymns are so strikingly similar to those found in the Psalms that I am satisfied, if an edition of the Psalms were prepared with a number of these interspersed, you would have to know them in order to distinguish them.

Here is a specimen which illustrates at the same time the method pursued in the purification ritual. The penitent comes to the priest, and, at the instance of the priest (and no doubt at his dictation), utters his confession. This one is addressed to Ishtar:

I, thy servant, full of sighs, call upon thee,
The fervent prayer of him who has sinned do thou accept.
If thou lookest upon a man, that man lives.
O all-powerful mistress of mankind,
Merciful one, to whom it is good to turn, who hears sighs!

At this point the priest takes up the refrain and addresses the goddess:

His god and goddess being angry with him, he calls upon thee,
Turn toward him thy countenance, take hold of his hand.

The penitent continues;

Besides thee, there is no guiding deity.
I implore thee to look upon me and hear my sighs.
Proclaim purification, and may thy soul be appeased.
How long, O my mistress, till thy countenance be turned toward me.
Like doves, I lament, I satiate myself with sighs.

The priest once more sums up the penitent's prayer:

With pain and ache, his soul is full of sighs;
Tears he weeps, he pours forth lament (?)

Then the penitent continues in another psalm:

The Lord has looked upon me in the rage of his heart;
A god has visited me in his wrath.
I seek for help, but no one takes my hand;
I weep, but no one approaches me;
I call aloud, but no one hears me.

These extracts will illustrate to you the ethical ideals the people had. It is perhaps not fair to judge a nation by its ideals, and it is interesting to see the various ways in which a people comes to reach these ideals. It is, however, the practice that after all furnishes the standard by which a people is to be judged; and here we have, on the whole, reason to feel that the Babylonians were a people that fairly carried out their ideals. Of course, there have been bad people at all times; and probably bad people were in the majority in Babylonia, as they may still be at the present time in the world; but, still, how do we know that, on the whole, the people carried out fairly the ethical

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principles laid down in this incantation that I have read to you?

The example of the rulers is always of great importance for a people; and if we read the inscriptions of the Babylonian and Assyrian kings (who had a great many faults, and who were very vain and very ambitious and in some respects even cruel), we find that they emphasize over and over again the thought that they are placed on the throne for the purpose of seeing justice done in the land.

Perhaps there is no king of Babylonia with whom we are so apt to associate cruelty and injustice as Nebuchadnezzar; yet this same king has left on record some of the most beautiful prayers, in which he emphasizes the fact that he feels that his purpose in life is to promote justice. Let me read the prayer of Nebuchadnezzar (addressed to Marduk, the chief god of Babylonia), upon ascending the throne:

O Eternal Ruler! Lord of the Universe!
Grant that the name of the king whom thou lovest,
Whose name thou hast mentioned, may flourish as seems good to thee.
Guide him on the right path.
I am the ruler who obeys thee, the creation of thy hand.
It is thou who hast created me,
And thou hast intrusted to me sovereignty over mankind.
According to thy mercy, O Lord, which thou bestowest upon all,
Cause me to love thy supreme rule.
Implant the fear of thy divinity in my heart,
Grant to me whatsoever may seem good before thee,
Since it is thou that dost control my life.

A king who does not hesitate to say, in the same inscription, that he, in dealing with a vanquished enemy, burnt hundreds of children and carried thousands into captivity and murdered tens of thousands, yet who sets up a prayer of this kind, must have had, at least, a sense of right. And the Assyrian kings, who were much more cruel than the Babylonians, also boast, in their inscriptions, of their goodness and righteousness; and, for instance, one of them says, deliberately, that when he came to Babylonia, he restored the lands which had been taken away from their rightful owners. The king furnishing an example of that kind—boasting of righteousness—is an indication to us that there must have been a feeling in the world that it was the proper thing for him to do.

There is a further illustration of the practical force of ethical ideals in thousands of little clay tablets that have been found in the soil of Babylon, and which furnish us an insight into the private life. The temples were the great storehouses of the archives. The priests were not merely the officials of worship, but were also the judges of the court; and the records of the courts in those days were kept by the priests in the temples. These temple archives consisted of thousands and thousands of these little pieces of clay, on which are found the records of lawsuits, of quarrels, of judicial decisions, of wills, and testaments—all such public business as was carried on in the various cities where temples stood. These little tablets give us an insight into the private life. They are the court records. In these tablets we find records of the law, the commercial and legal transactions; when houses were sold, the people came before the courts; there was a record made on these little clay tablets: "So-and-so bought this house from so-and-so; and it was situated in such-and-such a place." That in itself is an indication that there must have been a high sense of right and justice in the country. The development of legal phraseology, of the legal niceties, shows us that there was a strong desire in the country to promote justice.

There is one point which may be taken as a safe indication of the fact that, in a general way, the Babylonians tolerably satisfied an ethical ideal of life—and that is, that woman was practically the equal of man before the law. That seems natural for us; but it was only a short time ago when in the Occident she could not have her rights protected by the court. A woman could hold property in those days, which is a most remarkable fact. A woman in those days could also dispose of her own property, which is another indication of the position she held. The way in which woman was protected by the divorce law is remarkable. A husband could not, in those days, divorce his wife except for sufficient reason; and the reasons had to be better than some of those furnished in the State of Illinois. The son owed obedience not only to his father, which is natural, but he owed it also to his mother. And among the series of so-called family laws, there is a direct stipulation that "A son who says to his mother, 'Thou art not my mother'" (that is to say, a son who wishes to set his mother aside) is, in the first place, fined to a certain extent, and then driven out of the city.

This position occupied by woman in Babylonia is a safe index and standard of morality, and we may, therefore, feel certain that, while they no doubt failed—as all nations and modern peoples do—in reaching up to their standard, the kings emphasized, whether in the south or in the north, their desire to carry out righteousness and justice. And the existence of the large number of clay tablets, bearing the records of the courts in the meting out of justice and the position of woman in Babylonia, show that they fairly satisfied the demands that could be made upon an ancient people.

A monster blast took place in the quarries of the Welsh Granite Company, Trevor, Carnarvonshire, on Wednesday, December 7. The reason for the blast was that the rock was getting very tight and extremely difficult to get at. The quarry is situated at 600 feet above sea level, and the bank to be operated on was 100 feet high. The plans of operations consisted in driving in a heading about 15 feet above the level of the bank. This heading was 53 feet long. Another heading, 23 feet long, was driven to the left of this, and a chamber formed there. A further tunnel was driven to the right, but nearer to the mouth of the first heading. This one was 29 feet long, and a chamber formed at the end. There was very little report, and by measurement it was found that about 80,000 tons of rock were displaced, and fell on the bank exactly as prepared to receive it. A further quantity of 30,000 tons has been loosened. There were 6¼ tons of powder used as an exploding charge, and a small Siemens dynamo of 400 volts was used as the exploder. The operations were carried out under the superintendence of Mr. George Farren, M. Inst. C. E.

THE EVOLUTION OF A STRAWBERRY.

By L. H. BAILEY, Professor of General and Experimental Horticulture in Cornell University.

AT one time I planted roots of wild strawberries which I received from Oregon. I gave them a warm and pleasant knoll in the back yard and they grew and thrived. I had photographed the plants before they were set, and had taken botanical specimens from them. I made similar records of the plants after they became established in their new quarters, and at the end of two years I found that the distinguishing ancestral marks had disappeared, and I had a new type of plant. This discovery so delighted me that I told my friend of it, and said that I believed that I had really produced a new species. The friend, however, at once became serious and said that such a remark is heresy and that I should straightway look to my conscience. This staggered me. I had not thought of it before as a matter of ethics or even of philosophy, but only as a matter of fact; and I was astonished, as I now thought of it, to see how sinful a simple fact might be.

I returned to the strawberries on the knoll, where they lay so innocently in the sun; and were it not for my friend's suggestion and for the bees fighting in the blossoms, I should have seen no morals in them. It became evident, however, as I reflected on the matter, that I had made a grievous fault in my terminology. I had used the word "species." If I had said "kind," I had made no offense.

It is about this technical word "species" that the battles of evolutionists and theologians have raged for the last quarter century and more. The ancients did not know this species-conception, because they knew and cared so little for the external creation that they gave little thought to the kinds of animals and plants. But with the restoration of knowledge, nature came to be more and more an intrinsic thing, and persons began to wonder whence and why organisms came. With the attempt to describe or to inventory natural objects, there arose the conception of the "species" as something fundamental, a real entity or originally created thing. There was little attempt or desire to look at the external world broadly and to discover its method and meaning. The mind rested upon the objects, and naturally exalted them, and their direct progeny, into units in the creation. As there was no knowledge of whence and how these units came, they were conceived to be the direct and immediate handiwork of the Creator; and there was, therefore, no occasion for speculation or inquiry. This human formula of species-units was projected into the Mosaic record, as if that record read, "Let the earth bring forth species of grass," and "species of winged fowl." The idea of the finished and completed species-product became indelibly associated with theological teaching, and was—and, in fact is—a genuine dogma. If this species-dogma had not become so intimately associated with theological and biological beliefs, the hypothesis of evolution, when it finally came into the world, would have had few combatants.

But are they not species, after all? Surely there are the red maple and the sugar maple, the rose and the cabbage, the horse and the dog. True enough; but we now conceive these to be the products of evolution, the result of the creation, not the beginning of it. The great Linné's definition is typical of the older mind: "We reckon as many species as there were forms created in the beginning." That is, there are as many trees in a garden as have been placed there. When, however, we are no longer justified in assuming origins, we must base our conclusions on evidence. We shall then count how many trees there are in the garden, and we may find more or fewer than were placed there.

But I must not forget my strawberry. A hundred and fifty years ago a strange strawberry made its appearance in the gardens of Europe. Some persons said that it came from South America, and others that it came from North America; but nobody knew its history. Botanists considered it to be a good species, and it was named Fragaria grandiflora. This Fragaria grandiflora is well known to have been the parent of our common garden strawberries, yet the botanies are discreetly silent as to the nativity of the plant. Now the truth is that my little strawberry, taken from the woods of Oregon, turned into Fragaria grandiflora in two years! In Oregon it is known to botanists as Fragaria Chiloensis, for it grows in South America as well, and was named from Chilean specimens. If Fragaria grandiflora was a "good species" before my experiment, it was equally good afterward, and, as measured by the actual practice of botanists, I had caused a new species to be created from an old one. When I showed a botanist my results, he replied that the very fact that I had been a witness of this transformation is proof that the two plants are not true species. I replied that I was sorry that I had not closed my eyes when I passed the patch, and I also suggested that his species were founded upon ignorance of their origins; but he insisted, although himself an evolutionist, that my having caught the plant in the act was enough to excommunicate the form which had had the presumption to appear. My ethical friend had shown me the sinfulness of my little fact, and now the scientist had told me that observation is heresy; but the strawberry thrived.

It does not matter to the strawberry or to me whether it turned into a new species or not. It was a new thing or a new kind anyway; and this simple experiment on the sunny knoll has enabled me, as I verily believe, to reconstruct the genealogy of the garden strawberry. It is a modification of the Chilean strawberry, introduced into Europe by Capt. Frezier in 1712. The unnoticed modification of this strawberry under cultivation had added one more species to the infinitude of species; but my accidental discovery that the species was actually the result of modification has stricken that species from the lists; and thenceforth the backslider, if mentioned at all in reputable systematic botanies, must be only a variety or form of Fragaria Chiloensis. All this means that species are not, in practice, founded on essential or intrinsic characters, but the word is applied to any group of animals or plants which is so distinct from other groups that a name may be given it for convenience's sake. The name makes it possible for us to write and talk about the thing; but if we invest the name with assumptions of origins and genealogies, we are constructing for ourselves an idol which will enshackle us.

All this shows how personal a thing a species is, how much it is a matter of judgment of the man who makes it. Regel thinks that there are but two species of grapes in the northern hemisphere, whereas Munson considers that there are twenty-five species in the United States alone. Now the grapes are the same whether seen by Regel or Munson; but Regel is not Munson. In other words, species are matters of opinion rather than matters of fact.

It is so very important that the reader should understand the full meaning and consequences of the species-dogma that I illustrate it still further. Let us consider the exact methods of the naming of plants by an expert in any group. This group may be solidago, the goldenrods, and the botanist such an authority as Asa Gray. He has brought together all names and descriptions of goldenrods, has eliminated the duplicate or synonymous names, and has published a monograph of the American kinds, with the different species and varieties in definite and logical order. Nothing could be more precise than all this. The species are even contrasted, so that one stands against the other in the most clear-cut and emphatic way. Some one now sends him a dried specimen of goldenrod from the far West. Perhaps it can be referred at once to one of the given species or varieties, but the probability is that it will not fit any one of them. He first compares it with this species, then with that, and then with a third, and finally decides that it most closely matches a fourth. Another authority might have thought it most closely matched the second. The conclusion of the whole matter is that the description or conception of the species to which it is referred is modified to receive it. The naming of plants is a process of trying and fitting, and the descriptions are checked up by the plants, not the plants by the descriptions.

The reader may admit all this for the goldenrods or the grapes, to which he may have given little attention; but surely the red maple and the sugar maple are perfectly and clearly distinct. Perhaps; and yet I can bring specimens of each which I challenge the reader to name. The fact is that the layman generally sees—or notices—only the prevailing or type forms. He walks in the woods and makes a mental note, perhaps only half conscious, of a basswood, a beech, an elm, a bee, a black snake; but those individuals which have no designative or emphatic characters do not obtrude themselves on his attention. The naturalist, on the other hand, is trained to see the intermediates and the aberrant forms, and he, therefore, sees a different world than the layman does, even though both looked at the same things.

I must not be understood as saying that there are no distinct types in nature, or that it is an error to talk about species, or that there are always intermediate forms. My argument is that species are not original entities or things or starting points in the creation, but that the groups which, for convenience, we name as species are merely the present-time results of a long process of modification, and that these results have been produced by the contingencies through which the group has passed. Those types which are most pronounced and distinct are usually those in which evolution or change is most nearly completed; and those types which are unique are the ones in which has begun the slow decline that ends in extinction. The mastodon has perished, and the elephant is disappearing; the giant conifers of other ages are represented in the isolated groves of redwoods; the tulip-tree or whitewood, the sassafras, the ginkgo, all the ranks of cone-bearing trees; the scouring rushes are now a broken and ragged army slowly but surely marching to their doom. As they become less and less, as the changing environments and the inexorable grasp of time lop off the aberrant and sportive forms, these patriarchs become reduced to a single racial stem and, like the one remnant of a decaying family, perish at last into oblivion. What was once a chain becomes a series of detached and broken links; and the last and missing links comprise the proof that there was a chain.

But there is really no dispute among naturalists as to the fact of evolution. The controversy turns upon the means of evolution—the processes by which it has come about. Yet the reader—ye of little faith!—asks to see the process actually going on. I wish he could have seen my strawberries; but, then, he would not have believed his eyes if he had seen. Of course, the lifetime of a man is a short span in which to catch and to observe the movement of creation; but if my doubting reader will come with me into the fields, I will show him the process going forward. It is easy enough to see it, if one is ready to look and willing to believe what he sees. He will see it in the many intermediate and local differences in animals and plants. Here a plant grows stronger and there weaker, here erect and there decumbent, here it is small-leaved and there large-leaved, and so on through all grades of unlikenesses and combinations of unlikenesses.

Differences—or variations, as we technically call them—are the greatest facts in nature, but they are so common that, like the air and the sunshine, we have not discovered them until recent times. There are no two plants, nor even two animals, which are exactly alike; it must therefore follow, speaking broadly, that unlikenesses tend to perpetuate themselves. Now and then a strong variation, or sport, strikes off the main stem and we see it perpetuating itself year after year, a positive augmentation of differences which must in time arrive at that degree of difference which we are accustomed to regard as specific. In those groups in which progressive evolution is practically completed these new forms do not strike off freely. In fact, it is the lack of variation—the growing rigidity and inelasticity of the type—which has limited the group to extinction; for the moment that the organism refuses to adapt itself to new conditions, is that organism doomed. But sports are the exception. The creation has no doubt progressed slowly and steadily in the main, and it is still continuing.

There are numerous groups in which evolution is apparent to the close observer. These are the groups which are perplexing to the systematist. They refuse to fall into any scheme of classification, and rebel at

the paragraphing and versification into distinct categories (or species) to which, in an age of formalism, both the scriptures and the organic creation were submitted. Among common plants, some of these groups are the asters, brambles, goldenrods, cucurbitaceous plants, grapes, plums and their kin, and many of the sunflower-like groups.

An illustration of the making of a new species in the wilds may be taken from the genus Vitis, the grapes. In Texas and adjacent regions there is a grape known as Vitis Longii. There is evidence that it is a hybrid between two well known species, but it has spread itself more than two hundred miles beyond the ranges of its probable parents and often covers acres of ground as with a thicket. It has developed features which are unique, and it is probable that the intermediate or undefined forms are gradually being eliminated. It must, therefore, be regarded as a species. It is certainly a new type of grape, which is reaching out into unoccupied conditions. In my mind's eye I can see this type originating within the last century, and I can see its aberrations eliminated and its racial stem fixed into a close specific time within the next century.

The reader may be willing to accept all my remarks respecting the fact of variation, but he asks what proofs I bring that these varieties actually may be the beginnings of new species. In the first place, I must call attention to the fact that there is no difference between species and variety except one of degree. It is therefore a proper inference that the greater has come from the less. In the second place, we have the evidence of intergradient forms from very wide differences to very small ones.

Some of the best illustrations of the separating of two or more species from a parent stock are afforded by so-called geographical species. Let us turn again to the wild grapes. A certain species extends from the humid climate of the Atlantic seaboard to the arid country of Texas. It was first made known from eastern specimens and was named Vitis æstivalis. Later on, Texan specimens were described as Vitis Linsecomii. In these extremes the two grapes are perfectly well distinguished and have every merit to be ranked as distinct species. In the intermediate country, however, they merge and are indistinguishable. Therefore, for purposes of description and classification, one must be regarded as a variety of the other. If, however, a mountain chain or an ocean separated the two geographical regions, and thereby blotted out the intermediates, there could be no hesitation in awarding specific rank to each. This case is typical of the progress of creation; each geographical area has plants and animals peculiar to it, and in proportion as an area is disjoined and unlike others are its living forms peculiar and distinct. Scores of American plants are very like those of Europe, but the Atlantic Ocean so completely eliminates the possibility of intermediates that botanists regard the plants as geographical species. Thus we have another example of the fact that species may not be defined by intrinsic characters, but by personalities, and often in terms of mountains, plains and oceans.

But, to me, the best proof that small differences widen into great ones is the fact that I saw this result in my strawberry! I see it now as it grew on the sunny knoll—at first a squat, blue leaved, short trussed, densely hairy, bashful plant just brought into the East from the wilds of Oregon; then, the second year, a little more erect, the leaves thinner and more delicate, and a more confident and aspiring attitude; and the third year a tall growing, green leaved, high trussed, thinly hairy plant with ambitions to rival the garden strawberry. I began with Fragaria Chiloensis, but ended with Fragaria grandiflora; and I had the very same plants—the identical roots—to end with that I had to begin with, for I had sown no seeds and had not even transplanted the plants.

Fragaria grandiflora had already developed so far away from its parental species when it first began to be studied, a hundred years ago, that it could not be identified with that parent. Many garden plants and most domestic animals are further removed from their parental stems than the strawberry is, but history often supplies the connecting evidence and enables us to identify the offspring with the ancestry. But when history is silent, we may be able only to guess what the original form may have been, or we may say that the parental species is extinct. It is probable that very few of the original stems of our domestic plants are actually extinct, but the evolution has been so great that we can no longer trace it. It is a most significant fact that of very many of the common and long domesticated plants we do not positively know the wild originals. Of such plants are apple, peach, apricot, almond, orange, lemon, wheat, rye, barley, bean, wine grape, Indian corn, cotton, flax, sugar cane, tobacco, sweet potato, banana, pumpkin and squash, chrysanthemum, and a legion more.

I have now indicated in a most sketchy way a few of the evidences of evolution. I have chosen to speak of only the most familiar things, because they are seldom mentioned in contemporary writings, and because they seem to me to be the very best proofs of evolution. We have been looking so far into the past, have searched so diligently for great facts, have so urgently desired to see the missing links, and have so confounded ourselves with philosophy, that we have forgotten to go out and see the creation going on about us.

I cannot forbear to say a word about the missing links. Evolution is not a line; it is a genealogy. It is a tree of numberless branches, each branch forking again and again. The tip of one branch grows faster than its twin and thereby leaves the other behind; so that now we have in the world representatives of many of the stages of development. It is not unlikely that something very like the first forms of life still exist in the myxomycetes. The present groups of animals and plants are the tips of the branches in the multifid tree of creation. It is evident, then, that the missing links lie behind, not between. The genealogy is the missing link; and in many cases it is traceable. There are still many unfortunate persons who believe that Darwin taught that man came from the monkey. It is not to be wondered at that we sometimes think so. But the truth is, no doubt, that the two came off a single stem in ages past, and they now represent the tips of the branches of a letter Y; but I like to think that the human branch is a little longer than the monkey branch!—The Independent.

MYRMECOPHILOUS PLANTS.

IT is a fact well known to everyone that ants have the habit (a disagreeable one in gardens) of running over the surface of plants in order to gather the nectar secreted by the leaves and flowers, or else to "milk" the plant lice that live thereon. After they have finished their work, these insects retire to their nest and leave the plants for a moment at rest. There are cases, however, in which things do not proceed in this way, for sometimes the plant contains cavities of greater or less irregularity in which the ants pass their entire existence, the plant then affording them both food and lodging. In exchange for these good offices, it is admitted that the ants prevent their host from being overrun by noxious insects. In this hypothesis the plant is the "friend" of the ant, and is called myrmecophilous.

From a biological standpoint, the existence of these myrmecophilous plants presents a great interest by reason of the problems that it raises. It may be asked, in fact, whether the cavities were created for the ants or by them. We shall revert to this question further along.

The most benign case of this nature that can be adduced is that of various palm trees in the spathe of which ants live, but without producing any distortion therein. For instance, these insects select, in certain species of Dæmonorops, a domicile among the spines, which, inclining toward each other in several longitudinal lines, form genuine covered galleries or a sort of elongated huts.

The case of the Acacia cornigera is still more interesting. The leaves of this tree are provided at their base, in lieu of stipules, with two strong spines, which are so bent as to have been compared to the horns of an ox. The interior of these spines is hollow and is occupied by ants, which effect an entrance thereinto by making a small hole at the surface. The two cavities of the spines communicate with each other. The ants that dwell therein belong to the species of two genera; but these are never met with upon the same tree at the same time.

Upon certain trees the insect is the Pseudomyrmex bicolor, and upon others a Crematogaster. These two species gather the sweet substance secreted by the nectaries that dot the entire length of the principal petiole. Moreover, at the extremity of the leaflets, they meet with small buds that are at first compact but soon become succulent. When these sorts of little fruits are ripe, the ants cut them off and carry them into the spines in order to suck them at their leisure.

It is a fact curious to relate that, through culture (as Belt has ascertained), we obtain merely soft spines with pulpy contents, which no longer harden when they are invaded by certain kinds of ants. In order that they may acquire their full dimensions and hardness, the presence of the Pseudomyrmex bicolor or of a Crematogaster is indispensable. It will be seen that these two kinds of ants are useful to the Acacia, since, owing to them, the spines become formidable defenses against herbivora. The latter are, besides, repelled by the odor of the ants. In fact, the leaves of the Acacia, even when freed of their hosts, are not eaten by the herbivora on that account.

In the forests of Malasia we meet with a beautiful Euphorbiad, the Endospermum moluccanum, which also is myrmecophilous. Its trunk contains cavities that are inhabited by ants, which feed upon the nectar secreted by the petioles. This plant is so beautiful that Rumphius named it the "Royal Tree." It seems that its large dimensions are due to the excitation produced by the presence of ants. In fact, when it is cultivated in tropical botanical gardens, it can be made to acquire only a moderate size, whatever be the care bestowed upon it.

The interior of the stalk of one of the Verbenaceæ, the Clerodendron fistulosum, is inhabited by ants. The internodes of the stalk are much inflated, and their interior communicates with the exterior through an orifice situated just beneath the insertion of the leaf. Is this orifice the work of the ants or is it natural? Beccari, who studied the question, seems to think that it is natural, while inclining to the opinion that the aperture was originally the work of ants, but has become hereditary. However this may be, in order to convince ourselves of the services that the ants render to the plant, it will suffice to gather one of the branches, when the insects will immediately make their exit, run over our hand and inflict a painful bite.

The habitation of ants in the Nepenthes bicalcarata is more singular; it is the petioles of those curious pitchers that are considered as being designed to capture insects. The petiole under consideration is now straight, now curved, spongy and inflated, and its cavity (which does not communicate with that of the pitcher) opens externally through an orifice. The ants live in its interior. We meet also with a few openings upon the axis of the inflorescence of which the interior likewise is inhabited. It is curious to find that the ants select in the petiole the most dangerous place for them in the whole plant. If, in fact, they should venture upon the pitcher, there are many chances that they might slip into its interior and get drowned.

FIG. 1.—MYRMECOPHILOUS PLANTS.

1. Clerodendron fistulosum (inflorescence). 2. Stalk of Clerodendron. 3. Nepenthes bicalcarata: a, orifices. 4. Longitudinal section of an ascidium of Dischidia. 5. Ascidia of Dischidia.

In the Kibara formicarum we meet with a relation of another kind. In this Monimiaciad the internodes are filled with ants and coccinellæ. It is very probable that the latter are carried to this place by the ants, which derive a benefit therefrom by licking up the saccharine liquid that oozes out upon the surface of their bodies. It must be admitted that the presence of these coccinella "parks" in the interior of a stalk is very singular.

But one of the most curious myrmecophilous plants, and also one of the best studied, is certainly the Myrmecodia echinata. This epiphytal cinchonaceous shrub grows at a great height upon trees, to the branches of which it is attached by a few adventitious roots. It occurs in the form of large, irregular tubercles surmounted by a few leafy stalks.

These tubercles, which sometimes reach several inches in diameter, contain innumerable galleries, which all communicate with each other and open externally by several orifices. All of these cavities are inhabited by ants.

It would seem, à priori, as if these tubercles were pathological productions—galls produced by the irritating presence of ants. Such is not the case, however. According to the researches of Treub, the presence of the ants is very useful to the plant, which, so to speak, offers them a lodging of its own volition. If

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we cause seeds of the Myrmecodia to germinate, we shall obtain small plants that exhibit a slight inflation at the base. Now, even aside from the presence of the ants, this young tubercle presents a gallery which, at first internal, soon opens in order to communicate with the exterior. The ants are, therefore, not indispensable to the formation of the tubercle, which continues to grow and to form galleries. It is none the less true that the ants favor the great development of the tubercles, which, by their spongy nature, become valuable reservoirs of water for the rest of the plant.

Finally, we shall give, from a paper read by M. Heim before the Association for the Advancement of Sciences, a description of a curious myrmecophilic arrangement in the Dischidiæ. These plants are epiphytal Asclepiads of the extreme East, having twining stems and branches that wind around trees. They are especially remarkable by organs in the form of urns that hang from the twining branches and into which enter adventitious roots emanating from the peduncle that supports them. The resemblance of these urns to the galls produced upon the leaves of various trees by lice of the genus Pemphigus is such that a number of the first observers of these plants considered them as abnormal organs due to the puncture of parasitic insects.

The morphological nature of these curious organs has been perfectly elucidated by the researches of Treub, who has found that they are modified leaves. The normal leaves of the Dischidiæ are orbicular, thick, fleshy, and opposite. The urns are nothing but the limb of leaves of which the lower surface corresponds to the internal face of the urn. The petiole of

FIG. 2.—MYRMECOPHILOUS PLANTS.

To the right, Myrmecodia alata. To the left, Myrmecodia echinata (longitudinal section). At the bottom, various stages in the germination of Myrmecodia echinata.

this abnormal leaf is thicker than that of the normal leaves. The mode of formation of such organs may be understood by imagining the limb of a normal leaf to have been bent back toward the earth and then turned upright and its edges brought together. In reality, a change of growth manifests itself in the young urn in the way of formation.

The growth localizes itself nearly upon the median part, so as to cause it to assume the form of a hood, of which the opening is at first turned downward, and is afterward, progressively, more or less turned upward.

The Dischidiæ have opposite leaves, but the normal leaf opposite the urn aborts as a general thing. When the young urn affects the form of an elongated bag, a few adventive roots are seen to make their appearance upon its petiole. Those of the roots that grow near the mouth of the urn enter its interior. An adult urn ordinarily contains one or two long adventive roots provided with a well developed system of rootlets. The internal surface of the urn is purple, while the external is grayish or of a glaucous green, as is also the surface of the stalks and leaves.

The direction of the urns is variable and worthy of arresting the attention. The majority hang vertically with the mouth upward; but there are also some that are horizontal and others that are upright and that turn their closed extremity upward; that is to say, that preserve the position which they had at the time of their formation.

The urns of the Dischidiæ are often inhabited by ants. So Beccari asked himself whether it is not an irritation produced by insects (perhaps ants) that has determined the abnormal evolution of leaves converted into urns. Such distortion, at first accidental, may have become hereditary through the indefinite continuation of the phenomenon. That the prime cause of this abnormal evolution may have been parasitism is a sustainable hypothesis; but in the present state of things, nothing can now permit of attributing any role whatever, in the formation of the urns, to the stings of insects. However it may be with the role of ants in the production of urns, it is permissible to ask whether biological relations do not exist between them and the Dischidiæ, the urns of which they frequently inhabit.

Other insects but rarely enter the urns. The ants met with therein are always very lively and generally in very large numbers. The urns become genuine formicaries that shelter hundreds of individuals and many larvæ. The ants leave the urns with the same facility as that with which they enter them, since the latter present no arrangement apt to retain the insects that find their way into them. On the contrary, the adventive roots that traverse them from the petiole to the bottom form with their numerous radicles a sort of ladder leading to the exterior. When an urn that contains ants is pressed, the insects are seen to make their exit in large numbers, carrying their larvæ and nymphs. It is well to note that the Dischidiæ, according to the station, offer an asylum to ants or vegetate independently of all relations to them, and exhibit urns that are absolutely abnormal.

Upon the whole, there are numerous cases in which ants inhabit the interior of plants, but there is a long series of intermediate cases between that in which their presence is indifferent and that in which, if it is not indispensable, it is at least very useful. It is not impossible, even, to admit (as seems evident in the Myrmecodiæ) that the lesions produced for several generations by ants have become hereditary. In this regard, myrmecophily presents a great biological interest, since it shows us a fine example of the heredity of acquired characters and a true symbiosis between a plant and an animal.

For the illustrations and the above particulars we are indebted to La Nature.

The annual cost of keeping the pavements and streets of Paris in good order amounts to nearly 24,000,000f. Although wood paving is made use of, the streets of Paris are still largely paved with stone. The stone paving covers 6,040,000 square meters. Every year more than 100,000f. are spent in mending the roads, by resetting the stones. This work is carried out by the Association of Stonecutters at the average rate of 70f. per 1,000 stones; thus, nearly 1,600,000 stones are reset every year. The stone, asphalt, and macadam paving costs about 9,000,000f., and the wood paving costs 3,000,000f. to keep in repair. To these must be added the pavements and asphalted alleys, the cleansing of the public streets, etc., and thus the total cost amounts to nearly 25,000,000f. The average daily number of vehicles in Paris is 50,000, and consists of 1,600 omnibuses and tramcars, 15,000 cabs, 14,000 private carriages, 16,000 business carts, etc. According to the statistics taken by the municipality, the Avenue de l'Opéra is traversed every twenty-four hours by 36,200 horses drawing 29,500 vehicles, or 2,262 horses for every meter of its width. To support this wear and tear the roadways ought to be laid with granite from the departments of the Manche or Côtes du Nord or the North of France, or from the Vosges. The use of Belgian porphyry has been given up, as the passing of heavy vehicles renders it too slippery.

ACETYLENE.*

By VIVIAN B. LEWES, Professor of Chemistry, Royal Naval College, Greenwich.

FAMILIAR as I have been with chemical actions of all kinds, more especially in the development and use of gases, I shall never forget the impression made on my mind when, in the autumn of 1894, I first generated acetylene by the action of water upon calcic carbide obtained from Mr. Willson, in America. There was something almost "uncanny" in the development of this wonderful gas from the simple contact of the carbide with water. I was the more impressed by it as I had spent several years in researches necessitating the making of considerable volumes of acetylene, and I realized to the full the laborious and unsatisfactory nature of all the earlier methods for its production. It was with this carbide that I then made the experiments detailed by me in this room in January, 1895, when I showed you for the first time in this country the reactions which had caused me such keen delight, and also showed for the first time in any country how the gas could be consumed so as to develop to the full its marvelous illuminating power.

In the generation of acetylene from calcic carbide and water, all that has to be done is to bring these two compounds into contact, when they mutually react upon each other, with the formation of lime and acetylene, while if there be sufficient water present, the lime combines with it to form calcic hydrate.

(1.) Water. H_2O Lime.
Calcic carbide. $Ca \times C_2$ Acetylene. and

(2.) Lime. Water. Calcic hydrate.
$CaO + H_2O = Ca(HO)_2$

The wonderful simplicity of the reaction is its great beauty, and one would imagine that but little scope was afforded to the ingenuity of inventors in devising methods by which the contact between the interacting bodies should be brought about, but a glance through the patent literature of the last few years shows that where there is a will there's a way, and many of the weird devices protected under the name of acetylene generators would lead one to suppose that the formation of this beautiful illuminant was one of the most complex problems ever submitted to the ingenuity of man.

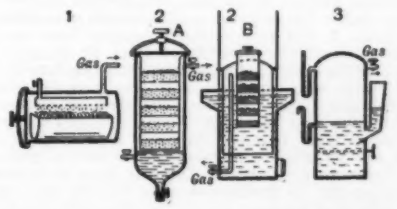
There are manifestly two methods by which the carbide and the water can be brought together—by adding either water to carbide, or carbide to water, while a slight amount of novelty can be introduced by allowing the water to rise in contact with the carbide from below, i. e., by adding the water to the bottom of the carbide instead of the top.

I showed these three methods of procedure when I first described acetylene, and at the time thought that the question of generators was practically done with, but within a few months the idea arose of making automatic generators, in which the space necessary for a small holder should be saved by making the apparatus only generate the gas as it was needed, and a multitude of devices for stopping the generation of the gas when the consumption ceased were designed and placed upon the market.

Unfortunately, the designers of these machines, although gifted with much ingenuity and mechanical skill, had but little idea of the properties of the body with which they were dealing, and as a result many of the generators, if not actually dangerous, are so arranged as to generate the gas in anything but its pure form, while some give a far smaller yield of gas per unit weight of carbide decomposed than others constructed on more rational principles.

The different forms of apparatus shown in the exhibition at the Imperial Institute, held in the summer under the auspices of this Society, may be taken as representing the best types on the market, and when in a few weeks hence the report of the committee is published, much interesting matter will be found in it. As a uniform quality of carbide was used throughout the exhibition for over a month's continuous working, direct comparison between the performances of the various generators becomes possible.

In considering the various forms of apparatus it will be well to divide them, in the first place, into two classes—(1) the automatic, in which the storage capacity for acetylene is less than the total volume of gas the charge of carbide is capable of generating, and which depend upon some special arrangement for stopping the action of water on the carbide when the consumption ceases; (2) the non-automatic, with which there is a holder of sufficient size to contain the whole of the gas generated from the charge of carbide which is used.



Each of these classes may be subdivided under three heads:

1. Those in which water is by various devices allowed to drip or flow in a thin stream on to a mass of carbide, the evolution of the gas being regulated by the stopping of the water feed.

2A. Those in which water in volume is allowed to rise in contact with the carbide, the evolution of the gas being regulated by the water being driven back from the carbide by the increase of pressure in the generating chamber, or—

* Lecture III. Delivered December 5, 1898, before the Society of Arts, London.

2B. By the rising bell of the gas holder drawing the carbide up out of water.
3. Those in which the carbide is dropped or plunged into an excess of water.

The points to be attained in a good generator are:
1. Low temperature of generation.
2. Complete decomposition of the carbide.
3. Maximum evolution of the gas.
4. Low pressure in every part of the apparatus.
5. Ease in charging and removal of residues.
6. Removal of all air from the apparatus before generation of the gas.

When carbide is acted upon by water considerable heat is evolved, and to determine what this amounted to, a good sample of commercial carbide containing 92 per cent. true carbide was experimented with as follows:

A rough calorimeter was made by jacketing a beaker about 5 inches in diameter with cotton wool. This arrangement, though crude, answered its purpose well, as experiment showed that some hot water placed in it only lost 0·2° C. after standing for ten minutes in a room at 18·6° C., a loss which could be neglected.

One piece of carbide the weight of which was known was dropped into a liter of water at a known temperature in the beaker, and the moment that the evolution of gas ceased, the temperature of the water was taken, the results being as follows:

Grms. of water taken.	Grms. of calcic carbide	Rise in temperature °C.	Corresponding calories liberated.	Number of calories liberated per gram of carbide.	Time of reaction in seconds.
1,000	42·7	17·4	17,400	407	62
1,000	28.9	11·4	11,400	394	91
1,000	19·7	8·2	8,200	416	73

which give, as an average, 406 calories liberated for each gramme of carbide.

Broken-up carbide, the pieces of which weighed from 1 to 5 grammes, was thrown into a liter of water in the beaker in quantities of 30, 40, and 50 grammes respectively—

Grms. of water taken.	Grms. of calcic carbide	Rise in temperature °C.	Corresponding calories liberated.	Number of calories liberated per grm. of carbide.	Time of reaction in seconds.
1,000	50	17·6	17,600	352	248
1,000	50	18·4	18,400	368	86
1,000	50	18·3	18,300	366	123
1,000	50	18·4	18,400	368	106
1,000	40	15·6	15,600	390	109
1,000	40	15·8	15,800	395	101
1,000	40	15·0	15,000	375	196
1,000	40	15·5	15,500	387	119
1,000	30	11·7	11,700	390	76
1,000	30	10·8	10,800	360	89
1,000	30	11·8	11,800	393	114
1,000	30	11·4	11,400	380	85

or 377 calories liberated for 1 gramme of carbide.

The last experiment was repeated with carbide still more finely divided, and the results gave 384 calories for each gramme of carbide.

From these figures it will be seen that, contrary to expectation, the smaller the carbide, the less was the yield of heat, but the reason for this can soon be made evident. More time is spent in weighing out the finer carbide than in taking the weight of one large piece, and the larger surface presented by the small pieces causes greater decomposition by the moisture in the air than with the single lump, hence the carbide is of poorer quality, and moreover the rapid evolution of gas in the case of the small carbide prevents the water abstracting all the heat from it.

Taking this into consideration, the 406 calories will most nearly represent the heat evolved by the decomposition of 1 gramme of good commercial carbide, and this would be equivalent to 414·6 calories for pure carbide.

With this figure as a basis, it is evident that the action develops about one-twentieth of the heat evolved by the combustion of carbon. As, however, the intensity of the temperature developed is a function of the time needed to complete the action, and as the decomposition of the carbide by water is extremely rapid, and the degree of heat attained varies with every form of generator, while the water in one form may never reach the boiling point, the carbide in another may become red hot and give a temperature of over 800° C.

When water drips upon carbide as in generators of subdivision 1, the temperature rapidly rises until it reaches a maximum after about 18 to 25 minutes, the actual heat developed depending upon the rate of flow of the water and the way in which it is distributed over the mass, but it is quite possible with generators of this class to reach from 400° to 700° C., and it is probable that in some parts of the mass the higher limit is nearly always attained, traces of tar being generally found in the residual lime. In some cases it is in sufficient quantity to make the lime yellow and pasty, while vapors of benzene and other polymerization products pass freely off with the gas.

Leaving the question of the temperature developed in this class of generator, another important point is the length of time over which generation of gas continues after the addition of water to the carbide has ceased. Makers of automatic apparatus of this type seem to think that in order to stop the evolution of acetylene, all they have to do is to cut off the water supply. This would act very well if the generation of gas really ceased then, but this is not the case, as the gas continues to be evolved, although with increasing slowness, for a considerable period after the cutting off of the water. The length of time over which this after-generation extends will, of course, to a certain extent, depend upon the amount of water added, the amount of carbide undecomposed, and the temperature of the carbide at the time when the water supply is stopped; while the generation will itself depend upon:

(a) The dehydration of the calcic hydrate first formed.

(b) The decomposition of water condensed from the gas present as the temperature of the generator falls.

As we have before seen, the first result of the action of water upon the carbide is the formation of quicklime and the evolution of acetylene, while if sufficient water be present, the lime takes up another molecule of water to form calcic hydrate. This molecule of water, however, at temperatures of 420° to 430° C., is driven off from the calcic hydrate, and the affinity of the carbide for any water present causes the reaction

$$CaC_2 + Ca(HO)_2 = 2CaO + C_2H_2.$$

A series of experiments was made by placing a known weight of carbide in a generating cylinder, running in a known weight of water in a given time, and carefully measuring the volume of gas for the first 10 minutes, and again when the action had practically ceased, and not more than 1 c. c. of gas was evolved in 10 minutes.

The results so obtained showed clearly that in any apparatus on this principle the cut-off should be so arranged that at least one-fourth of the total holder capacity is still available to store the slowly generated gas.

An important point was noticed in these experiments, viz., the large excess of water required to insure complete decomposition of the carbide over and above the theoretical quantity. The excess of water needed was largely dependent upon the form of generator employed.

According to theory, 64 parts by weight of carbide require only 36 parts by weight of water to completely decompose them and convert the lime into calcic hydrate.

This would mean that each pound of carbide needs a little under half a pint of water to complete the action, while in practice, owing to the evaporation due to the heat of the action, half the added water is driven off as steam with the acetylene, or left mechanically adhering to the lime, and the smallest quantity likely to complete the action would be a pint to a pound of carbide, while in reality the only safe way is to add sufficient water to drown the residue.

If this is not done, the lime forms so protective a coating to the carbide that small quantities often remain undecomposed, and if the residues are thrown into a drain or cesspool, the evolution of acetylene would give an explosive mixture, which, on account of its low point of ignition, would be a serious danger.

The second subdivision of generators (2A), in which water rises to the carbide, is very popular, and overheating can be avoided in these, provided they are so arranged that the water is never driven back from the carbide, and if the charge of carbide used is not too great. Under these conditions the slowly rising water is always in excess at the point where it decomposes the carbide, so that the evaporation by rendering heat latent keeps down the temperature, and although the steam so formed partly decomposes the carbide in the upper portion of the charge, the action is never sufficiently rapid to give any very great rise of temperature. In order to fulfill these conditions it is necessary that there should be a holder of considerable capacity, and that the leading tube conducting the gas from the generator to the holder should be of sufficient diameter to freely conduct away the gas, the water being allowed at the same time to rise in the generator so slowly as to do away with any risk of overgeneration.

In the best generators of this class these conditions are more or less approached, and it is unusual to find that the melting point of tin, 228° C., has been reached in the charge of carbide during decomposition.

Where apparatus of this class are automatic and have no rising holder to take the gas, it is found that they work satisfactorily when supplying the number of lights for which they were designed; but if they are overdriven and the action becomes too violent, excessive heating takes place, while the turning off of the gas and consequent driving back of the water from the carbide also has a tendency to cause it. If, however, the water has risen sufficiently slowly, the carbide below the surface has been practically all decomposed, so that the heating only takes place over a limited zone.

The generators of subdivision 2B are the worst offenders as regards excessive heating, the charge of carbide in some of them frequently becoming hot, while the lime taken from them is highly colored and often black from the formation of tar and carbon.

The moment that acetylene is subjected to the action of high temperatures, changes of great complexity begin. These at first are purely synthetical; at temperatures which are comparatively low the acetylene begins to condense to benzene; as the temperature rises, the condensation of four molecules of acetylene yields styrolene; a further increase in the temperature may cause the styrolene and benzene to interact, yielding anthracene and hydrogen, and it is probably at this point that the brown tar vapors appear, while naphthalene also is formed. At this temperature, morever, a fresh set of interactions start, the nascent hydrogen combines with acetylene to form ethylene, and this body under the action of heat breaks down into methane and acetylene once more.

When the outer layer of carbide decomposes, the gas is evolved so rapidly that there is no time for the heat to act upon it, but as the decomposition spreads into the center of the mass, the acetylene generated has to pass through the external layers, which, as shown, may be at a temperature above the point of its decomposition, and it is under these conditions that a considerable volume of gas is lost, and the tar, often found in the residue, or distilled out into the generator and tubes, is formed.

In generators in which excessive heating takes place, the tar is likely to cause considerable trouble, as it is of a very viscid nature, and if it condenses in the delivery tubes, causes the lime dust and carbon particles to collect and bring about stoppage.

A still more important evil, however, is to be found in the alteration which takes place in the composition of the gas, and which reduces its illuminating value to a serious extent.

Two samples of gas taken while the charge in one of these generators was overheating gave the following results on analysis:

	Per cent.	Per cent.
Acetylene	70·0	69·7
Saturated hydrocarbons	11·3	11·4
Hydrogen	18·7	18·9
	100·0	100·0

and such a mixture would only have about one-half the illuminating value of pure acetylene.

The large amount of hydrogen present in these samples also shows that decomposition of some of the acetylene has taken place, and a considerable deposit of carbon is often found in the generator.

At first sight these results seem an absolute condemnation of the second subdivision of apparatus, and the rising bell which draws a mass of wet carbide above the surface of the water is bad from every point of view. But generators in which water rises from below and so attacks the carbide can be made safe if the arrangements are such that the water is never driven back from the carbide, and the bulk of carbide is sufficiently subdivided.

The generators of the third class are those in which carbide is allowed to fall into an excess of water, and these have many advantages.

In such generators, as long as there is water present, it is impossible to get above a temperature of 100° C., unless lime sludge is allowed to collect at the bottom, when the carbide will sometimes get hot enough to melt zinc, but with a properly arranged tank the temperature never exceeds the air temperature by more than a few degrees. Under these conditions, the absence of polymerization and the washing of the nascent and finely divided bubbles of gas by the lime water in the generator yields acetylene of a degree of purity unapproached in any other form of apparatus.

The one thing that has militated against it is that it is not easy to design such a generator which shall be automatic, and as this seems to be the craze from which the generator makers are at present suffering, its advantages have been apparently overlooked by them, although fully recognized by all scientific men.

This form of generator, however, although exhibiting the great advantages enumerated above, has the drawback of being one of the least economical in the output of acetylene per pound of carbide used, as the gas, having to bubble through the water, is rapidly dissolved by it, while, in an apparatus in which only the surface of the water touches the gas, the amount dissolved is comparatively small. The result of this is that with generators of this class the generation rarely exceeds 4·2 cubic feet of acetylene per pound of carbide, instead of 5 cubic feet per pound.

As regards the complete decomposition of the carbide, it has already been pointed out that in generators of the first subdivision there may be a small quantity of the carbide left undecomposed, if water enough to flood the residuum be not admitted, while in non-automatic generators of the second subdivision this is practically impossible. In generators of the third subdivision, in which carbide drops into a large excess of water, it might be imagined that any carbide in the residue was an impossibility, but in point of fact this class is often the worst offender in this respect, as, if the generation has been in action for some time, a thick sludge of lime collects at the bottom of the generator into which the carbide sinks, and a large lump of carbide will often make for itself so tough a layer of oil and lime that it resists the action of the water, and is found unacted upon when the generator is cleaned out, the usual explanation given by the generator maker being that it is crust present in the "bad carbide."

In a good generator the maximum yield of gas should be evolved from the carbide. But a fact which the generator makers have entirely overlooked up to the present time is that, if you take a number of different machines, and supply them all with exactly the same carbide, no two will give the same yield of gas; the best generators giving volumes approximating to 5 cubic feet per pound of carbide, while the worst will give barely four—a result, as usual, placed at the door of the carbide.

The causes which tend to diminish the volume of acetylene given off are:
1. Undue pressure in the generator.
2. The acetylene after generation having to pass through a column of water.
3. Undue heating causing polymerization.

The first of these is very noticeable, and is due to the increased volume of gas dissolved by water under pressure, as although ten volumes of water at ordinary atmospheric pressure only dissolve eleven volumes of acetylene, at two atmospheres pressure it dissolves double the quantity.

When acetylene is generated at or above the surface of water, but little dissolves at once, the top layer of water rapidly becomes saturated, but when the gas has to bubble up through a mass of water, as in generators of the third class, a heavy loss from solution takes place.

The last cause has already been discussed, and is not so noticeable in its result.

The pressure in all parts of a generator should be as nearly as possible equal and as low as possible, and this is best obtained by working freely into a gas-holder of sufficient size.

The Home Office fixed 100 inches of water as the limit of pressure permissible in generators, but I think myself it was a mistake to allow more than 20, and I certainly should not advise the use of a generator which gave more than that amount.

Every part of the generator should be easily accessible, and complicated taps and valves should be avoided, while ease of charging and clearing should be attended to, ample room being provided in the generator for the increase in bulk which takes place when carbide is converted into lime.

One pound of pure calcic carbide yields 1·15 pounds of slaked lime, one kilo of carbide yields 1,156 grammes of slaked lime, and the volume this will occupy depends entirely upon the way in which the water is brought into contact with it.

In an automatic generator of the first subdivision, where water drips slowly upon the carbide in sufficient quantity to decompose it but not to flood it, the lime swells up and occupies from 2 to 2·5 times the bulk of

the original carbide; when, however, the water flows in more rapidly, the impact of the water beats down the lime and the space occupied is large.

In generators of the second type, in which water rises from below, the weight of the undecomposed carbide above it presses down the lime below and keeps it in a compact mass occupying about one-half more space than the carbide from which it was formed.

In designing a generator of the third subdivision, the tank containing the water into which the carbide falls should be provided with a false bottom so as to leave at least 8 inches to 1 foot of water below the point at which the carbide is decomposed for the lime sludge to settle in, and experiments were made to see the rate at which the settling of the excess of lime took place.

In these experiments known weights of calcic carbide were dropped into a beaker containing a liter of water, and the results obtained were as follows:

Water taken.	Calcic carbide.	Volume of Lime Paste deposited.		Volume of Lime Paste deposited, calc. for 1 grm. CaC_2.	
		30 mins.	90 mins.	30 mins.	90 mins.
Grms.	Grms.	c.c.	c.c.		
1,000	50	480	360	9·6	7·2
1,000	50	470	340	9·4	6·8
1,000	50	440	350	8·8	7·0
1,000	50	470	370	9·4	7·4
1,000	40	430	330	10·7	8·0
1,000	40	420	320	10·5	8·0
1,000	40	400	310	10·2	7·7
1,000	40	410	320	10·5	8·0
1,000	30	340	240	11·0	8·0
1,000	30	320	220	10·3	7·3
1,000	30	330	240	11·0	8·0
1,000	30	330	240	11·0	8·0
			Mean	10·2	7·6
1,000	50	450	340	9·0	6·8
1,000	50	440	330	8·8	6·6
1,000	50	450	330	9·0	6·6
1,000	50	440	320	8·8	6·2
1,000	40	390	310	9·7	7·7
1,000	40	410	310	10·0	7·7
1,000	40	390	300	9·7	7·5
1,000	40	390	300	9·7	7·5
1,000	30	310	210	10·3	7·0
1,000	30	300	240	10·0	8·0
1,000	30	240	230	9·6	7·6
1,000	30	300	220	10·0	7·3
			Mean	9·8	8·6

After 30 minutes the volume of lime was 10 c. c. per gramme of carbide. After 90 minutes the volume of lime was 8·1 c. c. per gramme of carbide. So that approximately after an hour's standing, each kilo of calcic carbide will give 10 liters of lime sludge, or 1 pound of calcic carbide will yield eight pints, which can be got rid of by a cock at the bottom of the apparatus. The rapidity with which settling takes place is, of course, slightly affected by the form of the apparatus.

Another requisite of a good generator, overlooked up to the present time, is that there should be an arrangement by which the air present in the generator can be rinsed out with some of the acetylene already made in the holder, or by some inert gas like carbon dioxide. I think this is a most important precaution, as recent researches by Mr. H. Gerdes show that, instead of acetylene requiring to be diluted with about twelve times its bulk of air in order to obtain the maximum pressure on explosion, mixtures of equal volumes of acetylene and air give the most powerful result. It must be remembered that the temperature at which acetylene decomposes into carbon and hydrogen with evolution of heat is 780° C., but the temperature of ignition is 480° C., and in such a mixture the degree of heat needed to cause explosion will more nearly approach the latter than the former temperature. It is quite conceivable that, in working on a big scale, the carbide might easily reach the necessary temperature while such a mixture of acetylene and air still remained in contact with it; indeed, I have come across several cases of explosion which could only be explained by this.

Working with 90 liters of the various mixtures in an explosion cylinder, and measuring the pressures by means of a manometer and indicator, the following results were obtained:

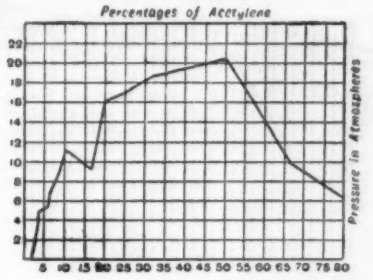
Pressures given by exploding mixtures of Acetylene and Air.

Per-centage of Acetylene.	Atmospheres Pressure.	Per-centage of Acetylene.	Atmospheres Pressure.
2·5	0·05	11·1	11·1
3·7	3·7	12·5	10·6
4·7	4·9	16·6	7·2
5·5	5·2	20·0	16·0
6·6	6·8	25·0	16·9
7·7	8·2	33·0	18·4
8·3	8·6	50·0	20·3
9·1	9·7	66·0	10·0
10·0	11·1	80·0	6·3

If these results be plotted out in a curve, it will be seen that there are two maxima of explosive force.

The first maximum of pressure occurs when completed combustion yields the greatest heat effect, and the acetylene is burned to carbon dioxide and water vapor, and this mixture explodes with the greatest noise.

Mr. Gerdes explains the second maximum of pressure by the assumption that the carbon is gaseous at the moment of liberation, but I do not think this theory is tenable. If a mixture of equal volumes of acetylene and air be ignited in an open cylinder 18 inches high, a lurid disk of flame runs down the cylinder and a vast cloud of carbon is given off, but no sign of anything approaching explosion occurs. If, however, this be done in a closed vessel, the very slowness of the combustion brings about the explosion, as the combustion of the portion of the mixture first ignited creates a pressure under which the remainder detonates at the temperature of combustion and gives the high pressure noticed in these experiments.



In experiments which I have made I have found it extremely difficult to ignite such a mixture of air and acetylene in a tube by means of an electric spark, but if a flask be employed so that a considerable volume of the mixture be present, the spark at once causes a violent explosion, the finely divided particles into which the glass is blown being an ample proof of the explosive force having been of an extremely sharp character.

The fact that a mixture of one volume of air and one volume of acetylene burns extremely slowly in an open cylinder, and also the fact that it is difficult to ignite by a spark the mixture in small portions, is no argument against the explosibility of the mixture, as if you take a mixture of carbon disulphide and nitric oxide in a short cylinder, it burns with simply a bright flash of light which is noted for its richness in actinic rays; whereas if a very long narrow cylinder be employed, it burns down to a certain point and then detonates, blowing the cylinder to pieces, such phenomena being entirely due to the increase in rapidity of combustion, which finally terminates in an explosive wave.

A good deal of the trouble arising in generators is due to the irregular development of the acetylene, which at first comes off with tremendous rapidity, and then, as the exterior carbide becomes coated with lime, gets slower and slower, while the after cracking off of this coating then gives irregular rushes of gas. Many attempts have been made to get over this trouble, perhaps the most successful being the decomposition of the carbide by means of a solution of sugar, which has the power of dissolving the lime as it is formed, and so gives a uniform and less rapid evolution of gas, but of course this increases the expense, and would only be available in the generators of table and bicycle lamps where cost is a secondary consideration; alcohol also when mixed with the water tends to regulate the generation. The effect of various oils in regulating the evolution of the gas has also been tried with a certain amount of success; as, if the carbide be coated with oil, it is protected from the action of water all the time the oil is clinging to the material; and in one form of automatic generator a layer of light oil is placed on the surface of the water. As the water rises past the carbide the oil rises with it, and the action of the water on the carbide commences a few minutes after the water has come into contact with it and has had time to displace the oil, while, on cutting off the gas, the water is again driven down. As the oil on its surface comes in contact with the partially decomposed carbide it is supposed to coat it and stop the after-generation. With very small generators working well within their capacities this may be successful, but with any large charge of carbide the heat remaining in the lumps of solid material would probably be sufficient to distill out some of the light oil employed.

In concluding this part of the subject I can only say that I believe that as time goes on the tendency on the part of acetylene consumers will be to use the simplest form of generator available with a holder proportionate to the needed consumption.

Abroad, a good deal of work has been done on the purification of acetylene, and, although this is desirable with the smallest installation, it becomes imperative when small towns or villages are to be supplied with acetylene instead of coal gas.

As was pointed out in the last lecture, the purity of the acetylene gas primarily depends upon the purity of the carbide from which it is formed, and as long as it is commercially impossible to use absolutely pure calcic oxide and carbon, so long will there be always present in this material calcic phosphide, calcic cyanide, aluminum sulphide, and magnesium nitride, which, on the decomposition of the mass by water, will yield a gaseous and unwelcome addition to the acetylene of phosphureted hydrogen, sulphureted hydrogen, and ammonia.

Phosphureted hydrogen, when it burns in the acetylene flame, gives rise to phosphorus pentoxide, which escapes into the atmosphere in the form of white fumes, and although the quantity is so minute that it is invisible as it leaves the acetylene flame, still, when mingled in quantity with the air of an ill ventilated room, it is the primary cause of the production of a light haze which, ever since the introduction of acetylene for illuminating purposes, has been recognized as a serious inconvenience in connection with it.

The atmosphere of a warm room always contains large quantities of water vapor derived both from the respiration of the occupants and from the products of the combustion of the illuminating flame, and under ordinary conditions this moisture remains suspended in the atmosphere in an invisible state, but as soon as traces of phosphorus pentoxide escape into it, this substance, having a marvelous affinity for water, causes a condensation of a portion of the water vapor and converts it into phosphoric acid; so that a very small trace of phosphureted hydrogen in the gas itself gives rise to an amount of haze totally out of proportion to the actual phosphorus present. Where there is a considerable quantity of acetylene consumed and no proper method of changing the air of the room, this haze will often be found, and it is undoubtedly injurious to health. I do not myself think that the whole of the onus of the haze can be laid at the door of the phosphureted hydrogen in the acetylene, but it undoubtedly plays an important part in this action upon which I am at present experimenting.

The sulphureted hydrogen formed by the action of water on the aluminum sulphide in the gas is objectionable, not so much because it renders the smell of the acetylene offensive, a function which I look upon as a safeguard, but because in its combustion in the acetylene flame it forms sulphur dioxide, which in ill ventilated apartments will absorb moisture and oxygen from the air, and will in this way become converted into minute traces of sulphuric acid, which, concentrating themselves upon any cold surface in the room in the form of impalpable moisture, give rise to corrosion of metals and in time to destruction of the binding of books, although the effect is but small upon such fabrics as have not the power of absorbing moisture or condensing it from the atmosphere.

The chief objection to the third impurity present in the acetylene gas—ammonia—is that it leads to rapid action upon the brass gas fittings, and is also an important factor in producing explosive compounds of acetylene with metals, although the experiments of Mr. Gerdes have shown that this is not a very real danger.

The ammonia, on burning in the flame, also forms nitrous acid, and when acetylene is burnt for some time in an inclosed space ammonic nitrite can be detected, and salts of this character may add to the formation of the "haze."

It is quite clear, however, that acetylene, if it is to be used on a large scale as a domestic illuminant, must undergo such processes of purification as will render it harmless and innocuous to health and property, and the sooner it is recognized as absolutely essential to purify acetylene before consuming it, the sooner will the gas acquire its deserved meed of popularity, while I think I shall be able to show in the next lecture that many other troubles will at the same time be overcome.

The only one of the impurities which offers any difficulty in removal is the phosphureted hydrogen. There are three substances which can be relied on to more or less remove this compound. The three methods are to pass the gas to be purified either through acid copper salts, through bleaching powder, or through chromic acid, and in experiments with these various bodies, it is found that they are all of them effective in also ridding the acetylene of the ammonia and sulphureted hydrogen, provided only that the surface area presented to the gas is sufficiently large.

The method of washing the gas with acid solutions of copper has been patented by Herr A. Frank, of Charlottenburg, who finds that a concentrated solution of cuprous chloride in an acid, the liquid being made into a paste with kieselgühr, is the most effective to be employed, and where the production of acetylene is going on on a small scale this method of purifying is undoubtedly the most convenient one, as the acid present absorbs the ammonia, and the copper salt converts the phosphureted and sulphureted hydrogen into phosphates and sulphides. The vessel, however, which contains this mixture has to be of earthenware, porcelain, or enameled iron, on account of the free acid present; the gas must be washed after purification to remove traces of hydrochloric acid, and care would have to be taken to prevent the complete neutralization of this acid by means of ammonia.

The second process is one patented by Dr. Ullmann, of Geneva, who utilizes chromic acid, which oxidizes the phosphureted and sulphureted hydrogen and absorbs the ammonia; while the third process owes its inception to Lunge, who recommends the use of bleaching powder for the purification of acetylene; but Dr. Wolff has found that when this is used on a large scale there was a risk of the ammonia present in the acetylene forming traces of chloride of nitrogen in the purifying boxes, and as this is a liquid which detonates with considerable local force, it occasionally gives rise to explosions in the purifying apparatus. If, however, the gas be first passed through a scrubber, so as to wash out the ammonia, this danger is got rid of, and Dr. Wolff employs purifiers in which the gas is washed with water containing calcic chloride and is then passed through bleaching powder solution or other oxidizing material.

The form of apparatus employed in the generation of acetylene has a remarkable influence upon the proportion of sulphureted hydrogen and ammonia present in the gas, although it affects but little the quantity of phosphureted hydrogen. A long series of experiments which I have made shows that when the acetylene is generated in machines of the third subdivision the ammonia is entirely eliminated, while the passage through the lime water reduces the amount of sulphureted hydrogen present to a mere trace, which may be neglected, but has little or no effect upon the phosphureted hydrogen.

Analyses given by Dr. Wolff of acetylene generated from American, German, and Swiss carbide as at present made give the following results:

	American.	German.	Swiss.
Phosphuretted hydrogen	0·05	0·03	0·03
Sulphuretted hydrogen	0·08	0·07	0·10
Ammonia	0·08	0·07	0·11
Hydrogen	0·09	0·07	0·16
Nitrogen.....	0·42	0·20	0·34
Oxygen	0·87	0·55	0·63
Acetylene	98·41	99·01	98·63
	100·00	100·00	100·00

While analyses which I have lately made from the ordinary commercial English carbide, and from the pure carbide made in France in the Herolt furnace by tapping process, are as follows:

	English carbide.	French carbide.
Phosphureted hydrogen.....	0·138	0·045
Sulphureted hydrogen.....	0·064	0·048

On taking a sample of English carbide and decomposing it by the dripping process, there is found 0·138 per cent. of phosphureted hydrogen and 0·064 per cent. of sulphureted hydrogen; while if this carbide is

allowed to fall into water, the acetylene so generated contains 0·126 per cent. of phosphureted hydrogen, and the sulphureted hydrogen is practically eliminated.

When the carbide is dropped into a solution of sugar the same result is obtained, and practically no sulphureted hydrogen can be detected in the gas so generated.

TYPEWRITER RIBBONS.

PERHAPS no part of the typewriting machine's equipment has given greater perplexity to its promoters than the ribbon. To obtain one that would not clog the type or smirch the paper, and from which the ink would not evaporate when exposed to the air, was a difficulty with which operators had to contend and which inventors tried hard to remedy. It is only within the last two years that ribbons have been made which appear to satisfy the general demand. While ribbons have been required since the time of the modern typewriter's introduction, it is in the last ten years that the business of making them has reached its greatest proportions. Four years ago it was said that this kind of ribbon-making was engaged in by at least forty manufacturers in the United States, and their output was estimated to be not less than 600,000 ribbons annually. To-day the annual production is probably more than twice as large as it was then, and makers declare that they are kept very busy filling their orders. The thousands of American typewriters used abroad are practically all supplied with American ribbons, and, as the average life of a ribbon is only about four weeks, their exportation constitutes an important branch of the business by itself.

Ribbons are made in almost every conceivable color and variety, and with copying and non-copying ink. Their length and width depend upon the requirements of the machine for which they are intended. The average length is 8 yards, although a few are made as long as 18 yards. Some ribbons write in one color and show an entirely different color when the writing is copied with a letter press. A ribbon which writes black may copy blue or green, making the record much more clear on certain kinds of paper than it would be if made in black. The head of the ribbon department of a large typewriter house on Broadway recently gave same facts concerning the extent of the business in question and the skill and care required in its prosecution.

"Here in New York," said the manager, "there are probably 500 places where typewriter ribbons are sold, while in all the cities of the Union there are many thousand. Some of the dealers handle eight or ten different styles, and the amount of their monthly receipts is often very large. The different makes of ribbons in the market number from fifty to seventy-five, and most of them are manufactured here in the East. I estimate that the number of ribbons used in a year ranges from 1,000,000 to 1,500,000. There is good reason to suppose that there are between 300,000 and 350,000 ribbon-using typewriters here and abroad, but, of course, some of the machines are not employed actively. I should say that fully one-third of the ribbons we make are exported, and there are also other manufacturers who export large quantities.

"Only persons connected with the business can understand how much care and expertness are necessary in turning out ribbons which will give good satisfaction. It is an easy matter to succeed in making a good ribbon now and then, or perhaps several dozen good ones, but that will not do; every single ribbon must be all right, or else complaints will surely be made, and the manufacturer will suffer in consequence. The effect produced by one poor ribbon might mean the loss of several customers who would be misled as to that particular brand.

"One of the chief aims of the manufacturers is to produce a ribbon which will leave a permanent impression on the paper. Ink which has lampblack as a base is always permanent; it cannot be extracted by acids and will not fade by long exposure to the light. The ribbons in most common use are the black copying, purple and purple copying, and a record made by any one of them may be regarded as absolutely lasting. Many of the best ribbons have selvaged edges, which prevent their raveling and curling when in use. They are nearly uniform in thickness, though some ribbons are made of very thin texture for use when a large number of copies is desired.

"The cloth of which the majority of ribbons are made is a very fine quality of 'jaconet' or nainsook, most of which comes from England and Germany. The ink is applied by means of rollers and is forced between the fibers of the cloth by revolving brushes. Then the surplus ink is absorbed, different methods being employed to accomplish that purpose. Each maker has a secret process for producing his individual ribbon, and the secret is guarded with the greatest possible care. The foreman of a ribbon factory is the only man there who knows the exact formula for mixing the powder or pigment used in making the ink; all the other employes do as they are directed by the foreman or by printed instructions.

"It is the rule in making ribbons to apply the ink to both sides of the cloth. One manufacturer, however, inks only one side, saying that ribbons inked in that way do not clog the type so often as those which are inked on both sides. His assertion might be true if the clogging was caused solely by the ink, but it is not. Little particles of the cloth are being detached constantly, which work into the type, and whether ink is present or not, the letters are bound to be filled occasionally.

"An effort has been made in Germany to make ribbons which would take the place of those imported from America, but the German manufacturer failed to induce the trade to accept his product. It will be a long time before our foreign friends are able to bring out ribbons which will supplant those made here, and our manufacturers have little cause to fear competition from that source."—American Exporter.

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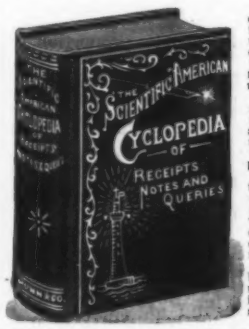

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TABLE OF CONTENTS.

PAGE

I. AERONAUTICS.—A New Flying Machine.—1 illustration 19335

II. ARCHÆOLOGY.—The Ethics of the Babylonians and Assyrians 19336

III. BOTANY AND HORTICULTURE.—Myrmecophilous Plants.—5 illustrations 19339
The Evolution of a Strawberry.—By L. H. BAILEY 19337

IV. CIVIL ENGINEERING.—The New Dusseldorf Bridge Over the Rhine.—2 illustrations 19339

V. CYCLES.—The Paris Cycle and Automobile Exhibition.—5 illustrations 19334

VI. ELECTRICITY.—Coast Telegraphs and Space Telegraphy 19338

VII. ILLUMINATION.—Acetylene.—By VIVIAN B. LEWES 19340

VIII. MECHANICAL ENGINEERING.—Boring, Threading, and Countersinking Machine 19339

IX. MEDICINE AND HYGIENE.—Sleep and What it Does for Us 19335

X. MISCELLANEOUS.—Some New Mechanical Toys.—3 illustrations 19339
Engineering Notes 19342
Miscellaneous Notes 19342
Selected Formulæ 19343

XI. RAILWAYS.—The Paris Metropolitan Underground Railroad 19331

XII. STEAM ENGINEERING.—A New Way of Constructing Steam Boiler Furnaces.—3 illustrations 19339
Suppression of Smoke 19331
Vertical Compound Engine.—2 illustrations 19331

XIII. SUGAR.—Old Time Sugar Making in Louisiana.—By Prof. H. S. HARING, S.J. 19339

XIV. TECHNOLOGY.—Typewriter Ribbons 19343

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